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RESEARCH ARTICLE OPEN ACCESS

Performance of Urban Transit in Jordan

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ABSTRACT
Urban public transit has essential and active role for sustainable and balanced socio-economic and environmental development. This study investigated the performance of urban public transit services in three major cities in Jordan, including Amman, Irbid, and Zarqa. Accessibility, mobility, productivity, punctuality, waiting time and comfort of public transit were investigated in the study. Data were obtained from Land Transport RegulatoryCommission of Jordan, municipalities, and field surveys.
The accessibility was found to be relatively low in Irbid and Amman city. 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. However, one-quarter of users' rated the comfort inside public transit as poor. Thus, enhancement of public transit service and introduction of new modes of transport are necessary to ease the existed urban congestion levels.
Keywords: Performance evaluation, transport means, bus, productivity, speed.

I. INTRODUTION

Jordan is located in the Middle East. According to the 2015 population and housing census, the country has a population of 9.5million, 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. Whilethe 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 means 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, Irbid, and Zarqa.Residents of these cities comprised approximately 70% of Jordan's population (Amir 2015). In fact, Irbid and Zarqa are considered as the second and third largest cities in Jordan, respectively. Performance indicators such as accessibility, mobility, productivity, punctuality, passenger waiting time, and comfort were investigated in the study.

II. METHODOLOGY AND DATA COLLECTION

In this study 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.

Table 1. Number of transit vehicles and number of routes in the included cities.

Transit mode	Amman	Zarqa	Irbid
Buses	529	-	-
Mini-Buses	349	560	833
Shared Service Taxis	3264	92	268
Total	4142	675	1129
Total number of routes	83	23	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, accesswas 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. Punctuality is measured depending on the actual arrival time and the scheduled arrival time (Patel, Gor 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.

Also, questionnaires were distributed to obtain data on users' response about comfort of transit. Comfort included cleanliness of seats, windows, and floors, as well as availability of air condition (Eboli, Mazzulla 2011).The field surveys were conducted for each transit route on Saturday, as a holyday 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 (Amir 2015). This field study was performed from Sep.,2014 to Jun., 2015.

III. DATA ANALYSIS AND RESULTS

3.1 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 is the limit of the served areas by public transit. Thus, only 41% of Amman area is 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 to be 63%. Therefore, the aggregate or overall accessibility of public transit service in Amman is only 63%.Investigation of Fig. 1 revealed that the outskirt of the city is not well served, thus extension of radial routes and addition of circumferential routs are required to improve accessibility.

Similarly, further accessibility analyses were made for Zarqa and Irbid cities. The results

revealed that only 21% of Zarqa area was served within a walking distance of 400 meters or less. In fact, most of public transit routes in Zarqa are radial, and many areas are under development. Population densities of new developments were unavailable, thus, no further analysis was made. While 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 Fig. 2). However, 91% of thecoverage 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 400m, 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.

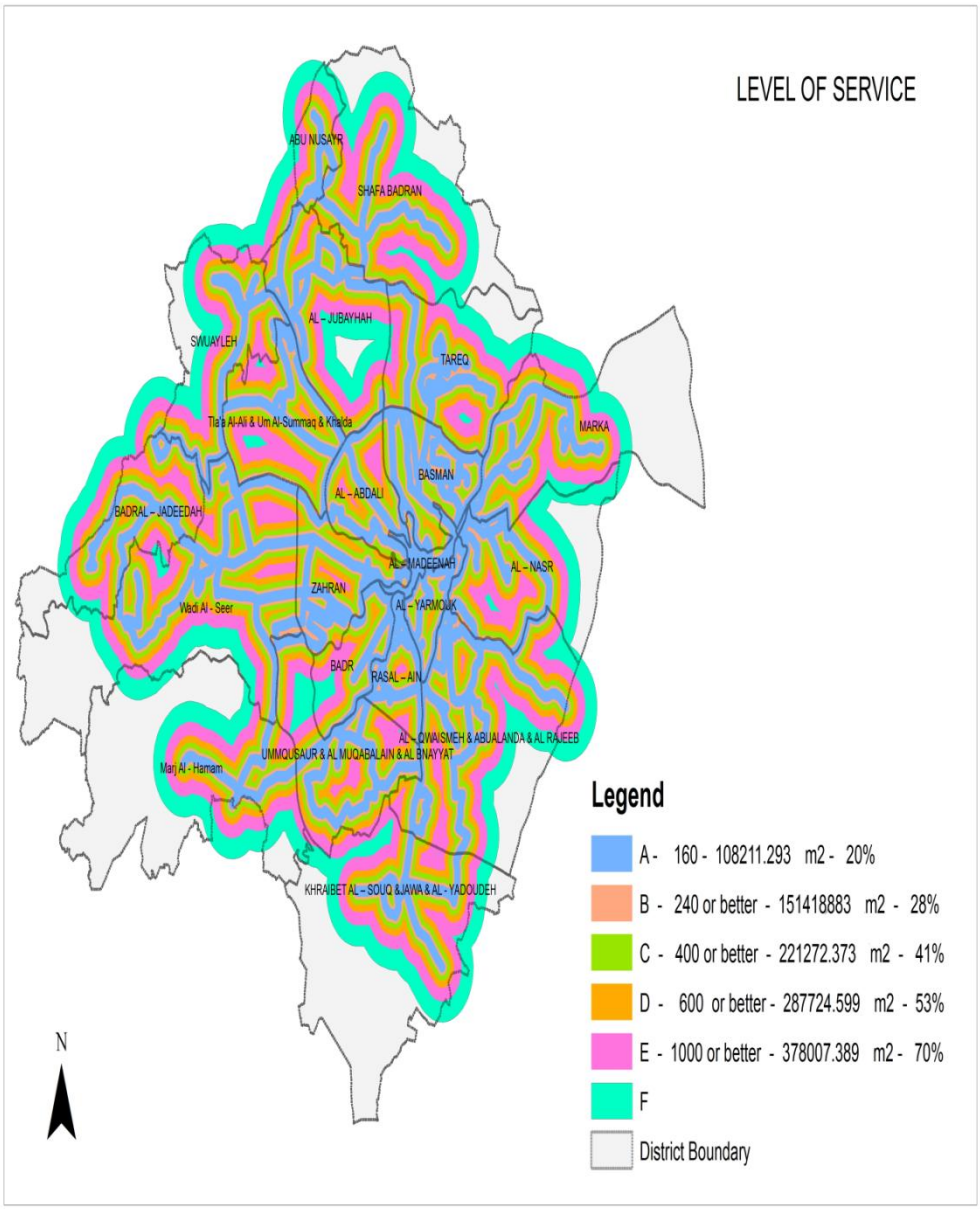

Figure 1: Coverage areas for public transit routes in Amman city.

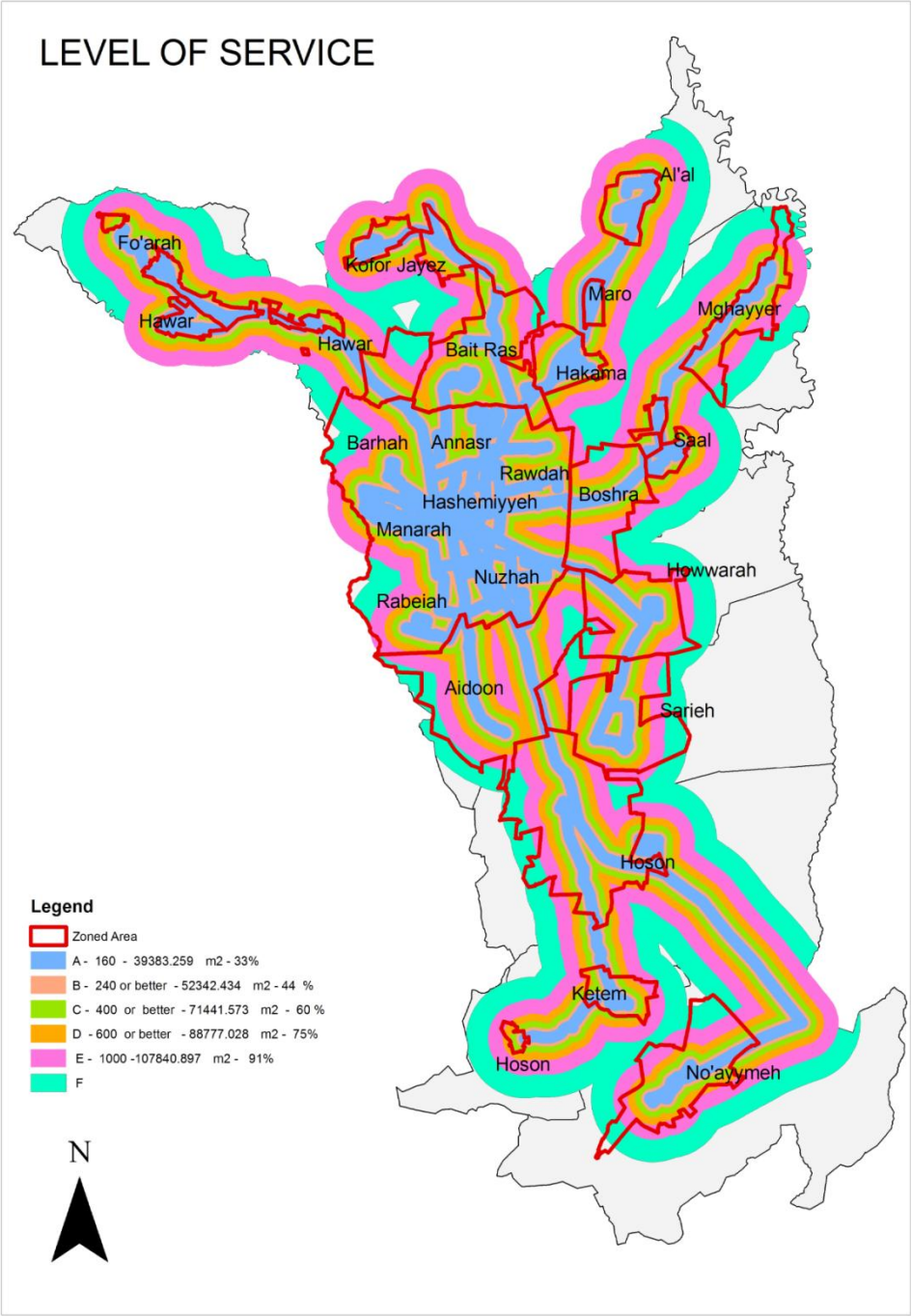

Figure 2: Coverage areas for public transit routes in Irbid city.

3.2 Mobility

Tables 2 shows the obtained results of average speed of public transit in Amman, Irbid, and Zarqa. 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	Bus	37	12	20/26	7	23/16
	Mini-bus	10	13	26/35	7	21/16
	Taxi	36	6	25/31	2	9/7
Irbid	Mini-bus	39	10.3	25/30	6	23/16
	Taxi	5	3.7	26/30	2	9/6
Zarqa	Mini-bus	22	6	24/30	6	17/12
	Taxi	1	4.8	31/38	2	10/7

3.3 Productivity

Analyses indicated that the operating ratio of buses in Amman was 3.8, while operating ratio of mini-buses, for all included cities, was approximately 3.7. In contrast, taxis had low operating ratio ranged from 2.3 in Irbid to 2.7 in Zarqa. 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. 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, Irbid, and Zarqa carried 320, 352, and 466 passengers per day, respectively. Furthermore, taxi vehicle carried 107, 124, and 240 passengers per day in Amman, Irbid, and Zarqa, 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 these results, it is recommended to replace taxis by buses or mini-buses as they have higher operating ratio and vehicle utilization.

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.

3.4 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.

3.5 Comfort

Users' responses about comfort inside buses were found to be similar in the investigated cities. Approximately 25% of users' rated the comfort inside buses as poor, while the remaining rated the comfort as accepted, good or very good. Thus, the majority of users' were found to be satisfied.

IV. CONCLUSTION

This study investigated the performance of urban public transit in three major cities in Jordan; including Amman, Irbid, and Zarqa. Results of analyses indicated that accessibility of urban public transit, within walking distance of 400 m, was relatively low. The mobility of buses waslow, while the mobility of mini-buses and taxis was found to be acceptable. Compared with the operating ratio for developed countries, the operating ratio of buses or mini-buses, in all investigated 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.Finally, approximately 25% of users' rated the comfort inside transit vehicles as poor. Thus, suggestions to improve transit services were made in this study.

REFERENCES

[1]. Amir Shtayat,"Evaluation of performance of public transit in Jordan", M.Sc. Thesis, Civil Engineering Department, Jordan University of Science and Technology, July, 2015.
[2]. Brookings Institute (2010). The Suburbanization of Poverty: Trends in Metropolitan America, Analysis of Transit Agency, Nielsen Pop-Facts, 2010.
[3]. Dublin Bus Annual Report (2011), Dublin, Ireland: Dublin Bus.
[4]. 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.
[5]. 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.
[6]. Govender, K. (2014). Exploring Public Transport Service Quality – The Caseof Mini-Bus Taxi Service In South Africa. *Mediterranean Journal of Social Sciences*, 8(10), 317-326.
[7]. Highway Capacity Manual, (2010). Transportation Research Board (TRB). Fifth Edition, (HCM 2010), Washington D.C.
[8]. Jason, C. Yu (1982),"Transportation Engineering". New York: Elsevier.
[9]. Murray, A. and Xiaolan W. (2003).Accessibility Trade-offs In Public Transit Planning.*Journal of Geographical Systems*, 5(1), 93-107.
[10]. Nakanishi, Y.J. (1997). Bus performance indicators: on-time performance and service regularity. Transportation Research Record, 157, 3-13.
[11]. National Transit Summaries and Trends, (2013). Office of budget and U.S.Department of Transportation. Federal Transit Administration Policy.
[12]. Patel, P. and Gor R. (2014).Improving Punctuality by Adjusting Timetable Design.*IJSRD - International Journal for Scientific Research & Development*, 2(2), 274-278.
[13]. World Bank. (2008). Design for All: Implications for Bank operations. Harold, Snider and Nazumi Takeda.Disability,Development, Social Protection and Labor.Human development network. Washington DC.

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