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Strategic Development of Transportation Demand Management in Jordan

Basim Jrew [a], Majed Msallam [b*], Mona Momani [c]

[a] *Ph.D. Professor, Department of Civil Engineering, Isra University, Amman, Jordan.*

[b] *Ph.D., C.E. Associate Professor, Faculty of Engineering Technology, Al-Balqaa' Applied University, Amman, Jordan.*

[c] *MS.c. In Engineering Project Management, Isra University, Amman, Jordan.*

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Abstract

The urban population growth and increase in a number of vehicles have affected the travel demand on Jordan Streets. The study aims to apply the Transportation Demand Management (TDM) policies to reduce the traffic flow in urban areas and improve the Level of Service (LOS). A group of a combination between TDM and Transportation System Management (TSM) strategies have been conducted, when TDM strategies were not successful to improve LOS. TSM concept refers to any group of actions that increase the capacity of roads network. Synchro 8 software was used to analyse the intersection conditions as important point, connecting two main arterial street in Amman area. A significant reduction in delay and fuel consumption was measured, but there was no real enhancement in LOS. The LOS was improved, when traffic demand was reduced by 20% and capacity was increased with 6 lanes on each approach for the existing conditions. The percentage of saving in fuel consumption and delay was observed to be around 64% and 63%, respectively for the next 5 years.

Keywords: Automobiles Crashes; Congestion; Fuel Wastage; Pollution; Transportation Demand Management.

1. Introduction

Amman is the capital and the largest city of Jordan. Therefore, the concentration of jobs is higher in Amman. The population in Jordan has been increasing at a constant rate. According to the recent most census of the population and housing of Jordan implemented in 2004 by the department of statistics in Jordan [1], the population was stood at 5.1 million people. The population is expected to reach 10 million in 2015. The universal fuel cost is a real problem because the costs are prone to increment in future. The financial expenses of importing petroleum are liable to increment, when generation of petroleum diminishes; while, universal ascent is in demand [2]. The people living in Amman were upset with the congestion conditions in peak hours as there is a long line of vehicles queuing and slowly movements on road. Traffic congestion is expanding at a rapid scale; thus, the environment can pollute and the commuters' trips can be delayed. It increases the travel time of passengers. The road traffic safety and efficiency can be improved through cooperative vehicular communications, which represents a promising technology [3]. The daily congestion on networks is the biggest problems that traffic faces in Amman. The urban streets in Jordan need a quick and immediate treatment and improvement. In the past few years, rapid growth in a number of vehicles has decreased the LOS. Whereas, the infrastructure and constructions are built to accommodate the demand [4].

The increased demand for transportation facilities is increased as a result of adopting effective transportation strategies. The demographic changes and car ownership provide basis for predicting the transport growth. It helps in

* Corresponding author: majed.msallam@bau.edu.jo

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providing road facilities for matching the transport growth. Recently, the traffic specialists have focused on managing the demand rather than managing the supply, while building new constructions. Travel Demand Management is an approach or activity that decreases the trip of vehicles or traffic volume for solving traffic congestion problems. This process is carried on by decreasing and restricting travel demand instead of increasing the transportation facilities. TDM refers to keep the capacity constant and reduce the demand or the strategies for managing the travel demand [5]. Thus, the study has combined the strategies between TDM and TSM to reduce traffic volume and increase the capacity on the high congested urban arterial streets, when the first strategy cannot be implemented for improving LOS.

The TDM has evolved as a policy to solve the problems related to growth and traffic congestion by restricting the travel demand. The demand cannot be fulfilled by providing an increased number of transportation facilities. TDM affects an individual's behaviour that presents alternative mobility options. TDM related programs are modelled on the basis of employer-based program that changes through the incorporation of specific performance objectives. The local ordinance law, individual firms, and means of conditions on development have mandated the TDM programs. It is important to study the concept of TDM and its benefits in the context of Jordan. The main objective of this study was to develop a strategy for decrease the traffic flow on urban areas instead of increasing the capacity by the implementation of TDM policies.

2. Literature Review

The existing roads and highways forming the TSM include the supply and demand sides. The supply side means changing the geometric design of the network and the transportation demand management means changing the users' utilization of roads [2]. Transportation System Management refers to any group of actions that mange transportation services and facilities for increasing the capacity of the roads network. The pedestrian facilities and improvements of traffic signals could represent effective TSM measures. Such measures increase the capacity on roads and decrease the vehicle delay. TSM is related to supply approach for increasing the performance of the system. A study conducted by Eikenberry et al. [6] examined the benefits as well as the challenges that enable and support sustainable modes of transportation. The results showed that making investments in sustainable transportation options are cost-effective. Comprehensive approach to TDM is made difficult as a result of approaches established for efficient transportation planning [6]. It can be accomplished through distinctive strategies; some of which incorporated traffic operation and control activities. Other strategies; like enhancing vehicle travel by special designation techniques would also be effective. In the Seattle downtown area, the studies have shown that the decrease in AM peak delay was noted when TDM strategies were applied for 152.849 vehicle-minutes. Figure 1 has described the results when the TDM measures were applied or not in Seattle on some route, with responding to delay performance measure. It also depicted the AM reducing delay in Seattle (U.S.A).

The need for options with respect to TDM strategies has been emphasized through the variations in employment patterns and commuting behaviours of the officials along the urban-rural spectrum [7]. Moreover, the decentralized work locations are not in favour of the labour workers as they focus on the traditional TDM strategies. It is important to utilize TDM policies for the reduction of traffic volume on roads. The Saudi government should take a proper care of public transportation system. A study by Sharif et al. [8] described the transportation system in Pakistan and narrated the two approaches of solving transportation congestion in it. In recent years, numerous strategies were applied in different countries of the world. Canada, Japan, and America are considered as good cases after application of TDM polices for reducing traffic volume [9]. The development of TDM strategies has a significant impact on reducing vehicle emissions and congestion. There are many reasons for the reduced usage of public transportation in Malaysia. The reasons included increase in income, fuel subsidies, population increment, and decentralization. The study has depicted how the citizens of Malaysia depend on the private motor vehicles; therefore, it led to huge increment in the number of vehicles including; motor cars, taxis, buses, motorcycles, and freight vehicles. Moreover, the transport related challenges including pollution, energy depletion, decline of public transport, environmental degradation, visual intrusion, and congestion have been experienced by the developing countries in particular [10].

Mahmood et al. [11] conducted a study in Bangladesh that focused on five strategies of TDM. The first one was to regulate the transit in large cities, like Dhaka. The old fleets were replaced with a new one, which had a double-decker or double buses as an immediate solution. Secondly, the traffic planners thought of using electrical buses or the buses powered with natural gas within five years. Thirdly, serious implementation of traffic rules and penalizing the violators was recommended. Fourthly, it depicts adjustment of the motor vehicles rules and application of heavier penalties. Lastly, it is concerned with development of a new network for the transportation demand [11]. According to The Driver and Vehicle Licensing Directorate in Jordan [12], the number of licensed cars in 2014 were about 1,331,563; and in 2015 about 1,336,667. The number of driving licenses was equal to 2,206,771. A study conducted by Hasnine et al. [13] adopted the concept of penetration rate, where a larger population is targeted. This provides an alternative approach to evaluate TDM strategy for its effective implementation. Table 1 has shown the evolution of population and vehicles between the years 1971 and 2014. It depicts that the rate of urbanization and car ownership in Jordan is increasing continuously. According to statistics from the Central Administration for traffic accidents, every 13th hours a person dies

because of an accident. The safety performance of roads in Jordan is declining continuously, while the number of fatalities has reached to 992 in 2007. Moreover, the increase in number of vehicles every year is likely to increase the number of fatalities to 1091 in 2022 [14]. Table 1 and Figure 2 have shown the growth of traffic since the last ten years.

According to a study conducted by alwrikat [15] the national days of urban transport meeting held in the ministry of transport on October 2015 has been discussed (Figure 3). The population of Amman is 3 million; and it is expected to rise about 6.4 million by 2025, which means the number of trips will increase from 6 million trips/day to reach to 12 million trips/day. There is 10.8% increase in the number of vehicles per year, and also 38% reduction in the fuel used in the traffic sector. Figure 3 has shown the percentage of private cars to be 34%. Special TDM measures have been taken in this study including; flexible office hours, compressed work week, etc. Results of the study have provided good understanding for TDM Policies. It has also provided a guidance to apply TDM policies and measure the effect of TDM on traffic system. Rahman and Al-Ahmadi [5] conducted a study for solving the transportation problems in Saudi Arabia by using TDM policies. TDM strategies are listed that can be implemented in Saudi Arabia; such as tele-working and E-government, electronic shopping, congestion and parking pricing, increased fuel pricing, preferential treatment of HOV, and using Light Rail Transit (LRT) [5]. The study emphasized on TDM strategies for solving problems, rather than the traditional transportation policies. The study has explained the meaning of TDM strategies and focused on the effect of TDM policies on car emissions and congestion.

Table 1. The evolution of population and vehicles through (1971-2014)

Year	Registered vehicles	Population	No. of vehicles per 100,000 inhabitants	Vehicle ownership
1971	26000	1.5 million	1733.33	vehicle for every 58 persons
2014	1331563	6.675 million	19948.51	vehicle for every 5 persons

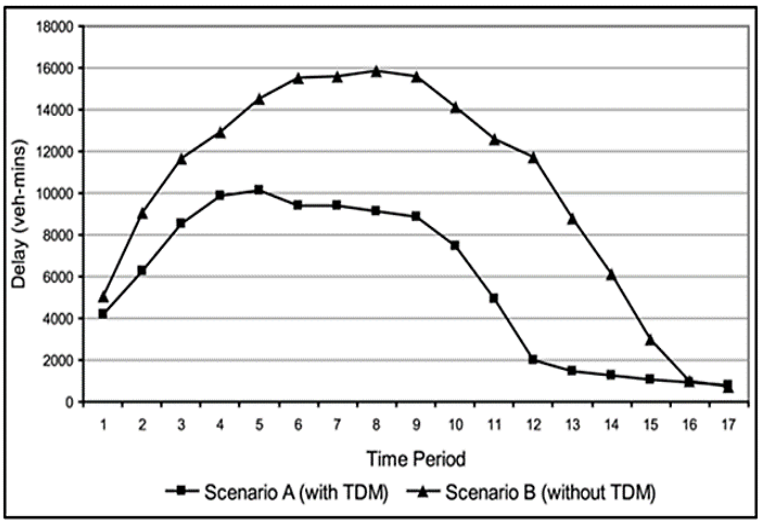

Figure 1. AM reducing delay on some route in Seattle (U.S.A)

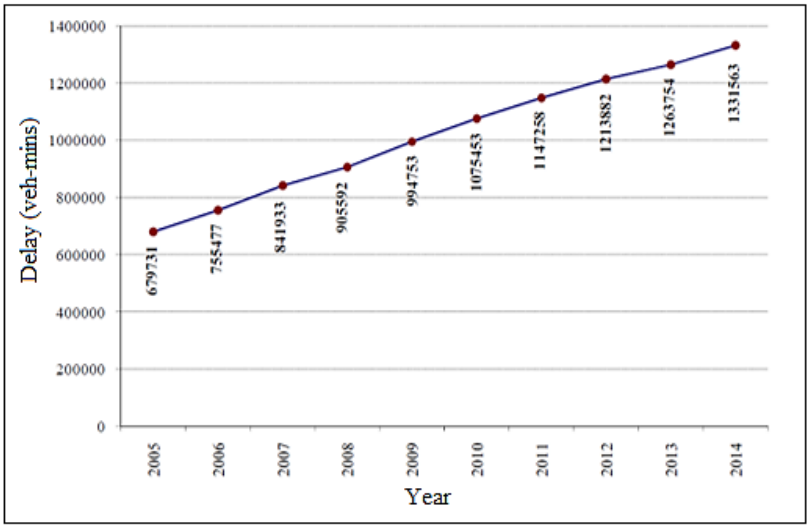

Figure 2. The growth rate of traffic volume in last 10 years. (With 7.8% growth rate) (The Jordanian Traffic Institute conference, 2015)

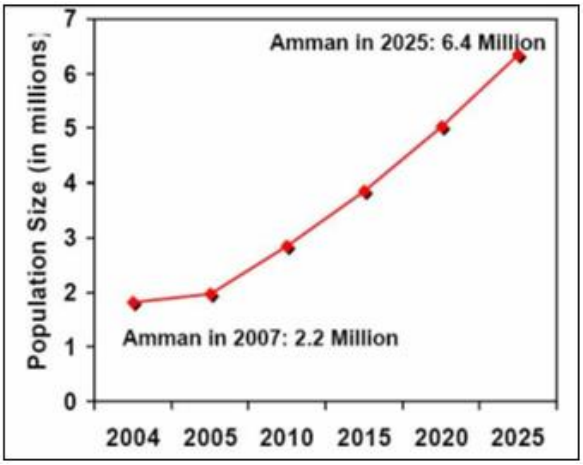

Figure 3. The population growth in Amman Jordan

3. The Case Study

The HCM-2010 has described six elements of the roadway network. These elements include point, segments, facilities, corridors, areas, and systems from smallest to largest. The case study selected in this study is based on a typical signalized intersection in Amman urban area. The intersection is a point on the urban street; therefore, it has been taken as a case study. Al-Bnayat intersection has been selected as a case study throughout the observation on Google Earth Application [17] as presented in Figure 4. The figure clearly shows that majority of the transport (34%) comprised on private or shared transportation. Whereas, minority (1%) included pick up vans and trucks.

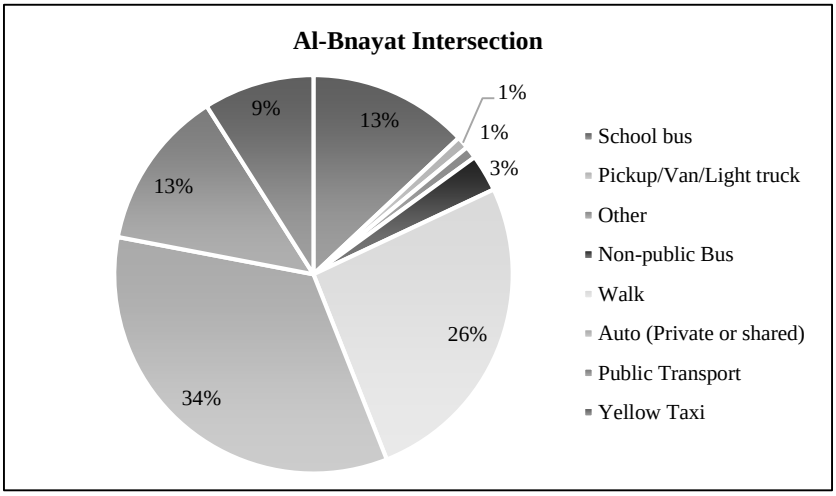

Figure 4. Al-Bnayat Intersection (Source: The Traffic Control Centre)

The selected intersection is Al-Bnayat intersection is located at Al-muqabalen region consisting of Al-Hurriah Street and Al-Quds Street. It has four major urban arterials streets including Al-Hurriah Street, Al-Quds Street, Abu-Baker Street, and airport road. Airport Street serve four universities and the passengers of Queen Alia International Airport connecting the commuters with Abdoun region in Amman. The intersection is located at Jordan Customs, which create heavy traffic volumes of passenger cars and heavy trucks each day. The surrounding area of the intersection is very important because it is located on heavy traffic Arterial Street and is surrounded with many important areas; like Airport Street. The data was provided by visiting the centre to determine the traffic volumes from the centre data base and monitoring the cameras at the centre. Some photos and videos were taken from the centre for the intersection. The traffic volume of each approach was collected every 60 minutes and every 15 minutes to calculate the PHF. The signalization conditions included the cycle length and the phases for each approach. The geometric conditions were determined from the field measurements.

4. Methodology

4.1. Data Collection

The data collection has been conducted through survey form and the questionnaire distribution. The statistical analysis was conducted through SPSS version 20. The analysis of questionnaire was validated by a group panel of specialists in transportation sector. The traffic condition data has been included to illustrate information about the

selected signalized intersection on an urban street in Amman, which signalize geometric conditions as a case study. The data collection required for analysis and evaluation was gathered from many sources. The first one comprised the questionnaire survey carried from the traffic and transportation engineers. The second source was from the Traffic Control Center at Amman Municipality Transportation. The third part was the expert panel that is a group of professionals in traffic area including, academics and managers from different universities and institutions in Jordan. The group of 17 experts conducted the survey form and validated the questionnaire. The questionnaire was designed on the basis of various studies mentioned in the literature review. The questionnaire was written in an easy language to be understood by the respondents. An Arabic form was also designed for decreasing the time of the interview. The questionnaire form was divided into three sections. The first part was having 19 TDM strategies, and the second part included 16 TDM and TSM strategies.

The participants gave answers to the general questions. The questionnaire was constructed in Likert scale and required the total population size; including 858 traffic and highway engineers. The reason of selecting this population size was because the study is concentrated in a special issue, which cannot understand from other group of the society in Jordan. The population size was determined from the Jordan Engineers Association. A sample design is an important step to obtain a sample from a given population [16]. Sample design was estimated before the data was collected. About 50% of the population size was selected randomly for the questionnaires.

The respondents to the questionnaire were 251, which means that more than 25% of the total population were respondents. The questionnaire was distributed to several government institutions and private companies. Majority of respondents were highway and traffic engineers, employers, and managers. The survey was conducted electronically via a link to an online survey and also through face to face interview, which lasted about 15 minutes. A total of 410 questionnaires were distributed, but only 251 had been fully recovered. The questionnaire was mainly distributed by face to face interview to traffic specialists and highway engineers at Greater Amman Municipality and the Ministry of Public Works at government sector. It was also distributed among the employees, working at private companies. The questionnaire was distributed to academics in many Jordanian universities. A group of specialists at the second monthly meeting held in The Jordanian Association for the prevention of traffic accidents also answered the questionnaire. The details about distributing the questionnaire has been presented in Table 2.

Table 2. Summary of distribution and respondents

	The Organization	Sent		Received		Response Rate %	Way of Distribution
		No.	%	No.	%		
1	Greater Amman Municipality	52	12.7	35	13.9	67	Interview
2	Ministry of Public Works	65	15.9	56	22.3	86	Interview
3	Private Companies	30	7.3	23	9.2	77	Interview
4	Academics at Universities	34	8.3	23	9.2	67	Interview
5	The Jordanian Association for the prevention of traffic accidents	29	7	27	10.8	93	Interview
6	Via e-mail	200	48.8	87	34.6	44	Internet
	Total	410	100	251	100	61%*	

*The table shows that 61% of the sending questionnaires are received which is more than the median level and it considered acceptable statistically.

4.2. Analysis of Data

The Statistical Package for Social Sciences (SPSS) version 20.0 was used to analyse the data. After contacting with a specialist in statistics issues, some results were related with reliability statistics, mean scores, one-sample t-test, and the one-way analysis of variance (ANOVA test). The statistics analysis was done twice; at first for the second part of the questionnaire, which was related to the strategies that reduce the traffic demand on the high congested urban arterial streets. At second, the analysis was done for the third part of the questionnaire, which included the strategies that relate to a combination between reducing the traffic volume and increasing the capacity on the high congested urban arterial streets. Cronbach's Alpha was developed by Lee Cronbach in 1951. It is an imperative concept to evaluate the questionnaires, and it validates the accuracy of the information. It ought to be noticed that the reliability of an instrument is nearly connected with its validity. Cronbach's Alpha is an index of reliability, where the reliability is defined as the correlation of test with itself. Its value is a numbered between 0 and 1. The acceptable numerical values of alpha are ranging from 0.7 to 0.95, depending on the nature of the study [16]. This part of the questionnaire included 19 strategies that decreased the traffic demand on urban roads. The congestion charging strategies was not conducted in this study. A survey was conducted in the public acceptance of congestion charging and road pricing measures according to a study by Jadaan et al. (2013). It was found that a 45% of respondents rejected the pricing policies at Jordanian roads. The (TDM) strategies mentioned in the questionnaire that reduce the traffic demand on high congested urban streets were as follows:

- Encourage the culture of transportation in groups and work using a single private car with 2- 4 passengers (Carpooling).
- Encourage using medium-sized car with 5 to 8 passengers (Vanpooling).
- Encourage using medium-sized of public and private buses with 10 to 20 passengers.
- Encourage using large public transportation buses with 20 to 40 passengers.
- The vehicles were contained by the official, semi-official institutions, and private sector.
- Provide financial incentives for employees and workers who are used the vehicles.
- Prohibit street parking on Main Street through the Coordination between the Ministry of Transportation, the Greater Amman Municipality, the Public Security, and the Traffic Department.
- Identify special lanes on both sides of the main streets for using by vehicles, after prohibition of street parking (HOVL).
- Allow street parking on the minor streets that are connected with the main streets.
- Develop an off-street parking lot with low prices and with distances of no more than 0.5 km along the sides of the main streets.
- Construct a multi-story building for parking (Parking Garage) with a distance of 1 – 2 km along the main streets.
- Encourage electronic work at home (On-line working or tele-working) with a rate of 10-20% of the workers at the departments and institutions in the private sector.
- Provide by low a special parking lot or parking garage for the entire government department and the private sector such as shopping centres, malls, schools, and universities.
- Encourage and activate the electronic service via the Internet or text messages (SMS) and the complete transactions of the citizens without personal interview, including the payment of taxes or bills.
- Send service instructions have been provided to all employees and workers posted on social media.
- Encourage on-line shopping or tele-shopping with special Delivery Service. (Delivery to home).
- Encourage using the coordinated mobility by using car first and then moving to the public transportation, by creating a parking at the beginning and the end of the transfer lines (Park and Ride) .
- Using (odd – even) system for a privet car only that allows cars ending in odd or even numbers for moving between day and other day (except taxis, public car, and buses).
- Development of legislation before planning for construction of any building that has to be constructed.

Cranach's Alpha value of these 19 strategies was 0.748, which is acceptable as it is above 0.7. The reliability level is achieved and the data can be used for further analysis. Another part of the questionnaire included 16 strategies that increase capacity and reduce the traffic demand on urban streets are as follows;

- Re-marking the main streets after using exclusively (HOVL).
- Remove Medians Island in main streets and replace it with yellow parallel lines or iron barriers.
- Increase the number of lanes by reducing the lane width to the limit of the specifications from 2 to 3 lanes or from 3 to 4 lanes in each direction of main streets.
- Prohibit moving the trucks in main streets during peak traffic periods and allow them to drive only during the evening periods to deliver the services.
- The routine maintenance work on the main streets must be during off-peak period and preferably in the evening time.
- The cycle length of the traffic signals was redesigned by using updated software based on the annual future growth of traffic density.
- Evaluate and improve the level of service (LOS) on the signalized and un-signalized intersections on main streets within LOS- C or LOC- D.
- Construct tunnels and bridges on the intersections including roundabout described in case when the level of service is not improved at LOS-E or LOS- F.
- A traffic signal is required with companions of the bridges and tunnels.
- Using of Intelligent Transport Systems Technology (ITS) on the main streets such as directional electronics signs guide the drivers in case of an accident, incidents, or bottlenecks redirection.
- Placing electronic sensors on the public transportation buses to increase the permitted green time of the traffic signals when approaching the intersection.

- Enforce the pedestrians to cross the main street through cross walk at the traffic signals or through pedestrian bridges that must be developed between the intersections.
- Improve traffic flow on some of the high congested main streets by applying the one-direction flow.
- Establish a legislation for the (Highway and traffic safety improvement programs) to reduce the accidents and the bottlenecks.
- Monitoring cameras need to be used for obeying the speed limit and follow driving rules to prevent any violations from the aggressive drivers which may reduce the capacity of the main street.
- Using the updated applications of information technology in traffic management and improve the traffic control divisions in Amman municipality.
- The Cronbach's Alpha value of these 16 strategies was 0.858. This value is acceptable because it is above 0.7.
- It was found that the strategy number 13 (Provide by law a special parking lot or parking garage) and the strategy number 14 (Encourage and activate the electronic service via the Internet or text messages) have the highest level of public acceptance (Table 3). The strategy number 18 (The odd - even strategy) has the lowest level of public acceptance.

Table 3. Ranking for the strategies that reduce the traffic demand on urban roads

No. of strategy	N	Mean	Std. Deviation	Scores	Rank
1	251	4.02	0.885	Very High	7
2	251	3.81	0.930	High	4
3	251	3.97	0.986	High	6
4	251	3.80	1.114	High	3
5	251	4.36	0.839	Very High	11
6	251	4.22	0.845	Very High	10
7	251	4.50	0.756	Very High	15
8	251	4.43	0.703	Very High	13
9	251	3.50	1.078	High	2
10	251	4.15	0.884	Very High	9
11	251	4.42	0.708	Very High	12
12	251	3.91	1.043	High	5
13	251	4.62	0.697	Very High	16
14	251	4.62	0.690	Very High	16
15	251	4.42	0.730	Very High	12
16	251	3.80	1.035	High	3
17	251	4.10	0.900	Very High	8
18	251	2.66	1.421	Moderate	1
19	251	4.47	0.689	Very High	14
Valid N	251				

*The strategies are numbered from 1-19 according to their appearance in the questionnaire survey

It was found that the strategy number 5 (The routine maintenance work on the main streets must be during off-peak period) and the strategy number 6 (Redesign of the cycle length of the traffic signals by using updated software based on the annual future growth of traffic density) have the highest level of public acceptance (Table 3). The strategy number 2 (Remove medians island in main streets and replace it with yellow parallel lines or iron barriers) has the lowest level of public acceptance. Based on these results, the strategies with very high score have been taken. 14 strategies were identified to be the most acceptable by the respondents and those strategies were accepted by the Jordanian society. All the strategies are accepted from the public except the strategies number 2 and 3.

5. Results and Discussion

The selected expert panel was selected as specialists in traffic and transportation field of Jordan. Some of the experts worked at universities and the others were working in consulting firms or at government administrations. A brief explanation of the study was included in the abstract of expert's panel. The abstract displayed the results of the

questionnaire. An expected reduction rate was described according to the results of the questionnaire results and transportation and traffic sector. A significant four rates were selected for the analysis on basis of the reduction rates given by the experts. These ratios of reductions were 5%, 10%, 15%, and 20% for analysis and improvement at the selected intersection.

5.1. Synchro 8 Software Results on Cased Study

Synchro 8 software was used to improve and analyse the traffic conditions and geometric conditions as a case study for Al-Bnayat intersection. The different stages associated with the intersection are as follows:

- Stage 1: Evaluation of the existing condition.
- Stage 2: Applying the optimization with existing condition.
- Stage 3: Decreasing the demand volume with 5%, 10%, 15%, and 20%.
- Stage 4: Applying the effect of growth rate for short term period for the next 5 years.
- Stage 5: Changing the geometric condition with demand reduction and increasing the capacity with the traffic demand mentioned at stage 3 (combination between increasing the capacity and decreasing the demand). The capacity was increased by increasing the number of lanes by 5 lanes and 6 lanes for each approach of the selected intersection.
- Stage 6: Repeat stage 5 with growth traffic volumes with reduction of 5%, 10%, 15%, and 20%.

5.2. Application of Synchro software output

Stage 1 was applied to evaluate the existing condition as shown in Table 4. In order to achieve accurate results, many optimization runs were conducted at the selected intersection with 5%, 10%, 15%, and 20% traffic volume reductions. The four streets considered in this analysis included; Abu-Baker Street, Airport, AL-Hurriah, and Al-Quds. The most congested area specified on the basis of results was the Airport; whereas, Abu-Baker Street was least congested. Significant difference in traffic reduction was observed among all the four street after 5%, 10%, 15%, and 20% reduction (Table 4). The results show that the LOS on the intersection is F, the delay is 243.6 sec/veh, and the fuel consumption is 1105 litre/hour (Table 5). The results indicated the worse existing condition on the intersection.

Table 4. Analysis process conducted by Synchro 8

Approach	Street name	Traffic Volume									
		Existing Conditions		5% Reduction		10% Reduction		15% Reduction		20% Reduction	
		L*	T**	L	T	L	T	L	T	L	T
1 (EB)	Abu-Baker	130	401	123	381	117	361	110	341	104	321
2 (NB)	Airport	526	1204	500	1144	473	1084	447	1023	421	963
3 (WB)	Al-Hurriah	399	1142	379	1085	359	1028	339	971	319	914
4 (SB)	Al-Quds	298	1184	283	1125	268	1066	253	1006	238	947

Table 5. The output results of the existing conditions of Al- Bnayat intersection

	Abu Baker street		Airport street		Hurriah-Al street		Al-Quds street	
Approach	EB		NB		WB		SB	
	L	T	L	T	L	T	L	T
Delay (sec/veh)	66.5	64.4	520.8	335.2	184.7	170.4	97.1	172.3
Approach delay (sec/veh)	64.9		391.7		174.1		157.2	
LOS	E	E	F	F	F	F	F	F
V/C Ratio	0.4	0.42	2.06	1.64	1.24	1.23	0.9	1.24
Intersection								
Intersection LOS	F							
Cycle length (sec)	180							
Delay (sec/veh)	243.6							
Fuel used (L/hr)	1105							

The optimization was repeated with growth rate of 7.8% yearly for each percentage with different geometric conditions (5-lane & 6-lane on each approach). All the results have shown that there is no improvement in LOS in all stages. Stage 6 was depicted as the final stage. The results showed that there was no improvement with the LOS, but

there was reduction in delay and fuel consumption. The delay at this condition was 134.2 sec/veh and the fuel consumption was 844 litre/hour (Table 6). The V/C ratio was improved in all approaches to have a significant saving in delay and fuel consumption. The percentage of saving in delay and fuel consumption was 63.6% and 64.8%, respectively.

Table 6. The output results of the traffic conditions with 20% traffic volume reduction, growth rate of 7.8% and 6 lanes on each approach

	Abu-Baker Street		Airport street		Al-Hurriah street		Al-Quds street	
Approach	EB		NB		WB		SB	
	L	T	L	T	L	T	L	T
Delay (sec/veh)	98.1	80.9	159.7	140.4	148.8	124.3	166.4	140.3
Approach delay (sec/veh)	83.7		143.5		128.3		144.5	
LOS	F	F	F	F	F	F	F	F
V/C Ratio	0.68	0.68	1.18	1.18	1.11	1.12	1.16	1.16
Intersection								
Intersection LOS	F							
Cycle length (sec)	180							
Delay (sec/veh)	134.2					63.6%		
Fuel used (L/hr)	844					64.8%		

*The percentage of saving is determined from the optimization of growth conditions.

6. Conclusion

The implementation of TDM measures has a significant improvement in performance measures on roads; such as delay, demand-capacity ratio (V/C), and fuel consumption. The final analysis by Synchro showed significant reduction on total intersection delays and fuel consumption. The strategies that aim to reduce traffic demand and increase the capacity have more acceptance as compared to the strategies that aim to decrease the traffic demand only. The LOS on the case study was not improved significantly because the selected intersection had the worst traffic conditions in Jordan and high traffic demand. TDM measures were applied on other intersection or urban roads, which had lower traffic demand. The traffic condition would be worse in the next five years with a traffic growth rate of 7.8%. Therefore, the ride-sharing strategies are very suitable strategies to be applied in Jordan. Congestion pricing strategy is not acceptable from public in Jordan; therefore, it needs extensive study to convince people for using this strategy. The study has contributed to the literature in two ways. The proposed approach is helpful for decision makers to select the most appropriate TDM strategy that could be applied on Jordan roads. It also specifies the importance of such strategies on urban roads, where there will be a significant saving in delay and fuel consumption. The efforts of all ministries and government institutions must cooperate together to solve the congestion problem in Amman by imposing the appropriate travel demand management strategies in Jordanian society.

The study in general can be implemented in different cities and with numerous scenarios of traffic congestion. Proper strategies, which have acceptance from the Jordanian society, can be implemented on other intersection and urban segments that would enhance the transportation network around the country. Continuous studies effect of TDM strategies with TSM can be implemented with ITS policies. Development of specific periodic maintenance of roads is necessary, where the routine maintenance work on the main streets must be during off-peak period and preferably in the evening time.

During peak traffic periods, the moving of trucks in main streets should be prohibited and allowed to drive only during the evening periods to deliver the services. When developing traffic programs, it is necessary to take into account the future population growth and increment in number of vehicles. The construction of new stores and malls should be restricted on the sides of the main streets. In order to prevent any violations from aggressive drivers, monitoring cameras are used for obeying the low speed limit and follow the driving rules, which may reduce the capacity of Main Street. The socio-economic factors are very important to be considered in the future research of TDM in Jordan.

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8. Conflicts of Interest

The authors declare no conflict of interest.

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Appendix I

1. Have you ever heard about TDM strategies before?
Yes
No

2. What is your opinion about these strategies (as described above)?
Very Positive
Positive
Neutral
Negative
Very negative

3. Age (years)
18 – 20
20 - 25
25 - 30
30 - 35
35 – 40
40 - 45
45 - 50
50 - 55
55 – 60
60 - 65
65 – 70

4. Gender:
Male
Female

5. Do you have a driver's license?
Yes
No

6. Do you own a car?
Yes
No

7. What is the level of your education?
Bachelor
Postgraduate degrees (Master .MA, PhD)

8. What is your current job?
Full time work
Part time work
Unemployed
Retired
Student

9. Sector you working in:
Private sector employee
Officer or director in the private sector
Government sector employee
Officer or director in the government sector

10. Income level in the Jordanian dinar:
Less than 300 JD
300 - <600 JD
600- <900 JD
More than 900 JD

11. I have problem with traffic congestion during my trip to work
Always
Sometimes
Rarely

12. My daily trip to work is during peak time of traffic flow
Always
Sometimes
Rarely

The following MCQ describe the transportation demand managements strategies, these strategies are divided into two sections:

- The first one includes strategies that reduce the demand on the high Congested Urban Arterial Streets and the second section includes strategies that increase the capacity on the high Congested Urban Arterial Streets.

Show your acceptance of each type of the strategies by choosing one of the following answers (Strongly agree, Agree, Fair, Disagree, strongly disagree).

First: Strategies that reduce the Traffic demand on the high Congested Urban Arterial Streets

No.	The strategy	Strongly Agree	Agree	Fair	Disagree	Strongly disagree
1	Encourage the culture of transportation in groups, from and to the work using a single private car with 2- 4 passengers. (Carpooling)					
2	Encourage using medium-sized car with 5 to 8 passengers. (Vanpooling)					
3	Encourage using medium-sized of public and private buses with 10 to 20 passengers.					
4	Encourage using large public transportation buses with 20 to 40 passengers.					
5	Provide the vehicles that were contained in paragraphs 2, 3, 4, by the official and semi-official institutions and by the private sector.					
6	Provide financial incentives for employees and workers who used the vehicles mentioned in paragraphs 2, 3, 4.					
7	Prohibit street parking on main street through the Coordination between the Ministry of Transportation, the Greater Amman Municipality, the Public Security and the Traffic Department.					
8	Identify special lanes on both sides of the main streets to be used by vehicles described in paragraphs 1,2,3,4 after prohibiting on street parking (HOVL).					
9	Allow street parking on the minor streets that are connected with the main streets.					
10	Develop an off-street parking (parking lot) with cheap prices, and with distances of no more than 0.5 km along the sides of the main streets.					
11	Construct a multi-story building for parking (Parking Garage) with a distance between (1 -2) km along the main streets.					
12	Encourage electronic work at home (On-line working or tele-working) with a rate of 10-20% of the workers at the departments and institutions in the private sector.					
13	Provide a low special parking lot or parking garage for all the government departments and the private sector such as shopping centres, malls, schools, and universities, etc.					
14	Encourage and activate the electronic service via the Internet or text messages (SMS) and the completion of transactions of the citizens without personal interview, including the payment of taxes or bills etc.					
15	Send service instructions described in paragraph 14 to all employees and workers and post on social media.					
16	Encourage on-line shopping or tele-shopping with special Delivery Service (Delivery to home).					
17	Encourage using the coordinated mobility by using car first and then moving to the public transportation, by creating a parking at the beginning and the end of the transfer lines, (Park and Ride) .					
18	Using (odd – even) system for a private car only that allows cars ending in odd or even numbers for moving between day and other day (except taxis, public car and buses.					
19	Developing a legislation for (Traffic Impact Study) for any building that is in plan to be constructed. Such as a commercial centre, shopping centre, hotels, hospital building etc.					

Second: Strategies that increase the capacity on the high Congested Urban Arterial Streets:

No.	The strategy	Strongly Agree	Agree	Fairly	Disagree	Strongly disagree
1	Re-marking the main streets after using exclusively (HOVL) described in first part (paragraphs 1, 2, 3 4).					
2	Remove medians island in main streets and replace it with yellow parallel lines or iron barriers.					
3	Increase the number of lanes by reducing the lane width to the limit of the specifications, from 2 to 3 lanes or from 3 to 4 lanes in each direction of main streets.					
4	Prohibit moving the trucks in main streets during peak traffic periods and allow them to drive only during the evening periods to deliver the services.					
5	The routine maintenance work on the main streets must be during off-peak period and preferably in the evening time.					
6	Redesign of the cycle length of the traffic signals by using updated software based on the annual future growth of traffic density.					
7	Evaluate and improve the level of service (LOS) on the signalized and unsignalized intersections on main streets to be within LOS- C or LOC- D.					
8	Construct tunnels and bridges on the intersections including roundabout described in (paragraph 7) in case the level of service is not improved. At LOS-E or LOS- F.					
9	If the implementation of what is stated in paragraph 8 and the roundabout remain operating at LOS-E or LOS-F. A traffic signal is required with a companion of the bridges and tunnels.					
10	Using Intelligent Transport Systems Technology (ITS) on the main streets such as Directional Electronics signs to guide the drivers in case of an accident, incidents, or bottlenecks to redirection the flow by the drivers.					
11	Placing an electronic sensor on the public transportation buses to increase the permitted green time of the traffic signals when approaching the intersection.					
12	Enforce the pedestrians to cross the main street through cross walk at the traffic signals or through pedestrian bridges that must be developed between the intersections.					
13	Improve traffic flow on some of the high congested main streets by applying the one-direction flow					
14	Establish a legislation for the (traffic safety improvement programs) to reduce the accidents and the bottlenecks that may occur.					
15	Using monitoring cameras to obey the low speed limit and to follow driving rules in order to prevent any violations from the aggressive drivers which may reduce the capacity of the main street.					
16	Using the updated applications of information technology in traffic management and improve the traffic control divisions in Amman municipality.					