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Estimation of New Development Trip Impacts through Trip Generation Rates for Major Land Uses in Palestine

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ABSTRACT

Trip generation is a basic component of transportation planning and plays a key role in conducting transportation impact studies. in Palestine, trip generation rates are not yet established and transportation impact studies for new developments are not yet adopted. This research aims to establish local trip generation rates for major land uses.

Field surveys were conducted in major cities in the West Bank, Palestine, based on international practices. A total of 138 sites comprising six major land uses were surveyed during the AM/PM peak periods using manual counting techniques.

Trip generation rates were established for the studied land uses considering the most appropriate independent variables. The study results were compared with the respective regional and international rates. It was found that the local trip generation rates were generally different (higher, comparable or lower). This can be attributed to the fact that travel behavior as well as socio-economic and land use characteristics are different.

The results of this research will form a basic step towards establishing proper transportation planning practices in Palestine and developing a trip generation manual. The research recommends coordination with key stakeholders to promote the adoption of conducting traffic impact studies at the policy level.

KEYWORDS: Transportation planning, Trip generation, Traffic impact studies, Transportation, Land use, Palestine.

INTRODUCTION AND BACKGROUND

Palestinian cities experience continuing traffic congestions that have resulted from increasing car ownership, high travel demand, low usage of public transport, inadequate transport infrastructure, among others. Poor transportation planning is another major factor contributing to traffic congestion and poor management.

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Generally, the classical urban transportation planning process considers the four-step planning approach. These steps are sequential and include trip generation, trip distribution, modal split (choice) and route assignment. Trip generation implies the estimation of the number of new trips generated; either produced by or attracted to new developments (projects). Therefore, the trips to be generated by a new development can be estimated through this process. Trip generation estimation is based on the rate of trips generated by a specific land use (development), which mostly depends on the size of the new development.

Among the variables considered in trip generation estimation are: area in square meters, number of employees and number of students.

Developed countries have established such trip generation rates for most land uses through field surveys of various land uses over the years. Some neighboring regional countries established these rates for selected common land uses. In Palestine, such a process is not yet established and no trip generation rates are estimated to forecast trips generated from such land uses. Furthermore, the use of trip generation rates from other countries, such as European countries and the US or even some regional Arab countries, might not be appropriate as the travel behavior and socio-economic characteristics are totally different. Therefore, it is crucially essential to establish these rates, at least for common land uses, to initiate a reliable transportation planning process that is adequate for the Palestinian context.

Transportation Impact Studies (TISs) are used to analyze the impacts of new developments on the transportation systems in terms of available infrastructure and traffic systems. Therefore, future problems can be predicted, thus mitigation measures would be identified and then implemented. As such, several countries require the submission of TISs as part of the permitting procedure of major development projects.

Limited transportation impact studies were carried out in the Palestinian areas, where *ad hoc* trip generation rates were used in these studies, as will be presented later. The reliability of locally developed trip generation rates in these studies is somewhat questionable, as they were based on surveys of limited sites for a limited period; consequently, they were subject to random occurrence and were not statistically significant. Therefore, it is essential to develop reliable local trip generation rates at least for major land uses, which would be a step in the right direction to promote reliable transportation planning and to promote the adoption of Transportation Impact Studies within the permitting process, especially at the municipal level.

The establishment of trip generation models or rates is not a direct and easy task, as it requires the collection of representative data from different locations, in order to use such data to estimate reliable models or rates. Due to lack of available data in Palestine, as in many developing countries, a plan for collection of relevant data needs to be prepared and implemented.

The paper presents first the objectives of the research and the study area. This is followed by a review of selected literature indicating the experience in developed as well as in developing countries, the methodologies followed and the outcome of such studies. Next, the methodology followed in collecting data and in analysis is illustrated. Then, the paper presents the conducted field studies and the data analyses. Expected research impacts are presented and comparisons with international rates are conducted before presenting finally the conclusions and recommendations.

Objectives and Study Area

The overall objective is to promote reliable and sound transportation planning practices as a way to manage the transportation system and to provide preventive solutions to transportation problems before they occur. This would be achieved through the development of local trip generation rates and their characteristics for major land uses, including residential, commercial, office, school, hospital and hotel uses.

The research covers the entire West Bank. The traffic impact of major developments is critical in large cities, as the traffic condition is already congested and cities are faced with limited space for infrastructure expansion. Therefore, focus is placed on major cities; however, the survey covers cities where developments with the required characteristics already exist. Furthermore, the study takes into consideration the geographic distribution of the samples (developments) to be surveyed.

Based on the points noticed above, 14 cities were considered in the study. These cover all the regions in the West Bank as follows:

- The northern region of the West Bank, including the six main cities of Nablus, Jenin, Tubas, Tulkarm, Qalqiliya and Salfit, forming the administrative centers of the six governorates in the region, in addition to Bedia city in Salfit governorate.
- The middle region of the West Bank, including the three cities of Ramallah, Al-Bireh and Jericho, forming the administrative centers of their respective governorates in the region.
- The southern region of the West Bank, including the two cities of Hebron and Bethlehem, forming the administrative centers of the two governorates in the region, as well as the cities of Beit Jala and Beit Sahour in Bethlehem governorate.

The study locations are shown in Figure 1.

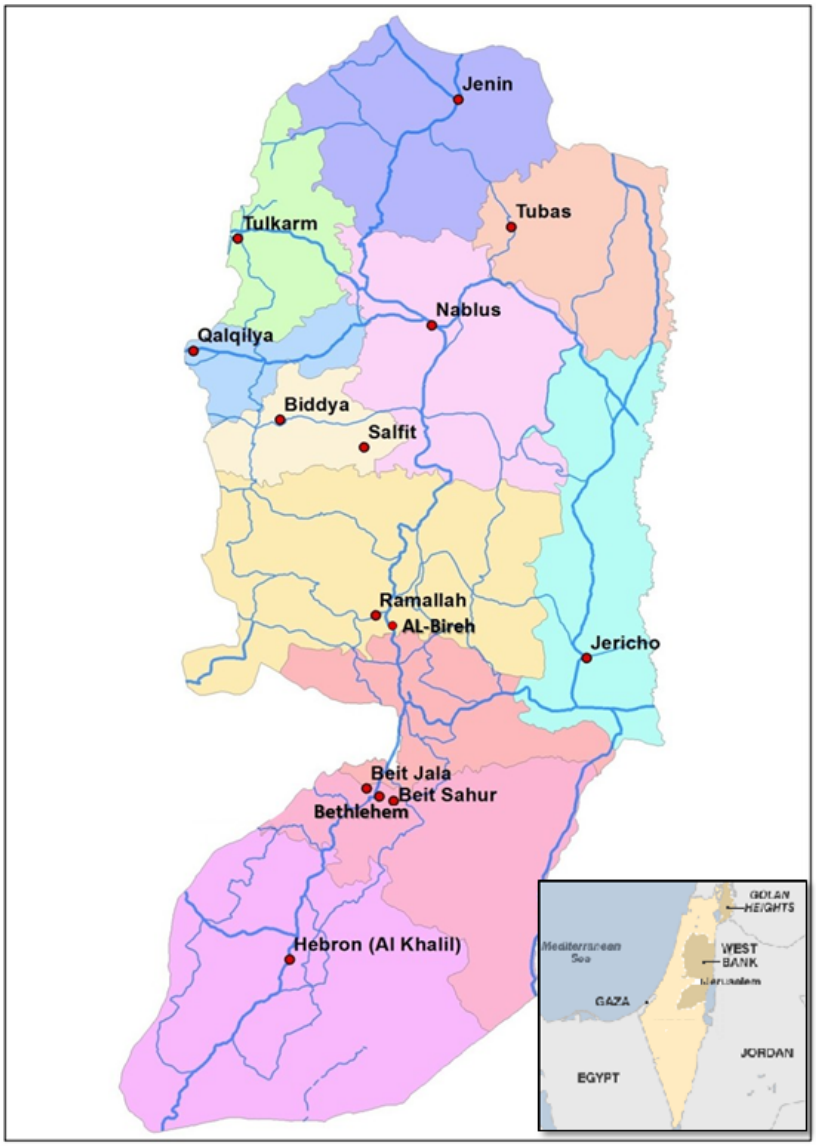

Figure (1): A map illustrating the West Bank cities included in the study

Literature Review

Trip generation is widely used for forecasting travel demands. It predicts the number of trips originating from or attracted to a particular traffic analysis zone of specific use(s).Trip generation analysis focuses on key land uses, such as residential, commercial, industrial, as well as school, hospital, hotel and other special land uses. A trip is often defined as a one-way single journey made by an individual between two points by a specified mode or combined modes of travel and for a defined purpose (Ben-Edigbe and Rahman, 2010). Trip generation relates the number of trips generated by a land use or a facility with other relevant variables.

Numerous studies were conducted and books were published in various parts of the world, especially in the developed countries, to establish trip generation rates or equations. However, all these represent the travel characteristics of the area where the surveys were conducted. Similar efforts, though to a lesser degree, were also conducted in the developing, including Arab countries. On the Palestinian side, this has been very limited.

Trip generation studies have been conducted since the 1960s in the USA and Canada and from that time vehicular trip generation data was collected and analyzed until the Institute of Transportation Engineers (ITE) published the first edition of Trip Generation Manual in 1976, which contained trip generation rates for 50 land uses and more than 500 studies without graphical plots. Since then, the ITE Manual has become the most widely and internationally recognized reference for estimating trip generation. In 2012, the ITE published the 9th edition of this manual with 172 land uses and more than 5200 studies (ITE, 2012). The percentage of inbound and outbound trips, as well as daily, AM and PM peak hour trip rates or equations are detailed for each land use. This manual could be used in several fields, such as traffic impact analysis, impact fees, roadway design, signal timing and environmental assessments. The Trip Generation Handbook, which is part of the Trip Generation Manual, is a guide that describes the methodology and procedures to conduct trip generation studies, in addition to several important factors related to trip generation (ITE, 2012).

Several US states and jurisdictions have established localized trip generation rates for development approval based on observed characteristics in their communities (e.g. Montgomery County Planning Board, 2013; City of East Lansing, 2008; City of San Diego, 2003).

However, it has to be indicated that the ITE Trip Generation Manual is often criticized for its inability to account for multimodal behavior in urban contexts, where overestimation of vehicle traffic is observed (e.g, Kimley-Horn and Associates, 2009; Vermont Trip Generation Manual, 2010; Majbah Uddin et al., 2012). Research has been developed for adjusting the ITE's vehicular trip generation estimates for the urban context using household travel surveys, as well as nationally available built environment data (Clifton and Currans, 2015).

The explanatory variables' set, which has been found in the literature regarding trip generation analysis, ranges from socio-economic and demographic attributes of the household to the built environment characteristics and land-use patterns. Researchers found that the automobile trip generation rate for the neo-traditional neighborhood is significantly lower than for the conventional neighborhood, because individuals rely on automobiles partly to travel from place to place in conventional communities, since land uses are separated and spread out. By contrast, when certain design features, such as higher development densities and continuous sidewalks, are combined with the mixed land uses typically found in neo-traditional communities, many expect residents of these communities to drive less and walk and bike more on average (Mousavi et al., 2012).

In developing countries, the manuals of South Africa and the United Arab Emirates (UAE) can be considered as representative examples of developing countries' manuals dealing with trip generation rates for various land uses. In several other developing countries, research has been conducted to deal with specific land uses.

The South African Trip Generation Rates document published by the South African Department of Transport (2007) identified the trip generation rates for various developments. It identified the factors that influence the trip generation production and; therefore, proposed vehicular trip rates per unit of the factors. However, such rates have limitations, as these were defined to be, for the residential land-uses for example, dependent on the income level. Peska and Venter (2009) investigated alternative independent variables to define residential trip generation, where other independent variables were selected for investigation, such as size and density of development, as well as size of units. Compared to the rates published in the South African Trip Generation Rates document (South African Department of Transport, 2007), average trip rates were found to be less, necessitating a more in-depth relook at trip generation rates and procedures.

In the UAE, the Emirate of Abu Dhabi also published its own trip generation manual (Abu Dhabi Road and Transit Authority, 2012). The manual contains trip generation and parking demand rates for various land uses existing within the Emirate of Abu Dhabi for the cities of Abu Dhabi, Ein and others for CBD and non-CBD areas. These rates were obtained through the survey and analysis of nearly 400 different sites throughout the Emirate. The manual considers trip generation for 82 sub-categories distributed over nine general groups of land use developments. Other Arabic Gulf countries have also published their own trip generation manuals.

Naser et al. (2015) developed trip generation rates for hospitals in Amman, Jordan. Twenty-one hospitals in the city of Amman were surveyed during average weekdays. The study related trip generation with specific descriptive information about the hospital including its area, number of beds and number of available parking stalls. This study showed that trip generation models developed in the ITE trip generation manual do not produce accurate estimates that could be used for proposed hospital sites in Jordan. The study developed various forms of trip generation models, including single-variable regression, multi-variate regression and multi-layered perception algorithms. The data analysis showed that the number of patient beds and the gross floor area were the main factors affecting hospital vehicular trip generation.

In Palestine, such official rates or approved TIS procedures are completely lacking. Few transport impact studies were conducted for major developments in the West Bank; these were either as initiatives by the developer to anticipate future transportation problems and their appropriate mitigation measures (Awadallah and Al-Sahili, 2008; Al-Sahili, 2010; Abu-Eisheh and Al-Sahili, 2013) or requested by the municipality on a non-obligatory basis (Awadallah, 2011).

Trip generation rates used in these studies relied on very limited surveys of few (sometimes only one) local facilities in Ramallah/Al-Bireh city area and for few hours for one or two days. Therefore, from the scientific point of view, the results are statistically insignificant and randomness is involved. In addition, one facility does not represent the typical characteristics of the respective land use. All these studies used manual counting of vehicles in their surveys. These projects also established that the overall characteristics of local trip generation are quite different from those published by the ITE Trip Generation Manual.

METHODOLOGY

The methodology used in this research was mainly based on the ITE (2012) methodology. A primary part of the research depends on field survey of trips generated by specific land uses. Therefore, the first step in this regard is to identify locations (cities and facilities) where the survey will be conducted. This also included preparation of survey forms, locations and maps.

The selection of land uses and survey sites is the major step where the targeted facilities will be surveyed. Each candidate facility was visited by the survey team to investigate its appropriateness for the survey and for the study purpose. Furthermore, ITE (2012) suggested some criteria for identifying the sites within the study

area, which were considered in the site selection process. These criteria (for each study site) include:

- It should satisfy the definition of land use.
- It should be of reasonable full occupancy (85%).
- It should be mature (at least 2 years old).
- Necessary data can be obtained readily and accurately.
- It should be in an area with no unusual activities underway.

Furthermore, the sites were selected to be outside the city CBD, where many activities interact and overlap, thus it is difficult to separate traffic for a specific facility from the adjacent others in the CBD areas.

The ITE (2012) recommends that at least three (preferable five) sites should be surveyed and higher number of sites is suggested based on the time and budgetary constraints. Six or more facilities were surveyed for each type of land use in different locations through the West Bank. Comprehensive geographic distribution of the surveyed facilities was also taken into consideration.

The size of the surveyed facilities in terms of square meters, number of employees, number of residential units, number of students, number of rooms, number of beds,… etc. was surveyed as well. This was obtained by interviewing the facility owner/manager.

Field survey was conducted for two typical workdays for each facility during the morning (AM) and afternoon (PM) peak periods of adjacent street traffic. Inbound and outbound trips for the specific land use were also surveyed. Manual traffic counts were conducted for at least 2 hours for each peak period and the researchers avoided making counts during special events, holidays, bad weather or any other time when the conditions at the study site are abnormal, because it could affect the site's trip generation.

Based on all of the above mentioned points, special forms were carefully designed for the field surveys. A pilot study with small-scale zone and sample size was performed before the larger study was fully carried out, in order to test the logistics and information gathering process. The survey forms and procedure were modified based on this pilot study.

Based on the field survey, data was consolidated into an appropriate format for further analysis. Trip generation rates and associated statistical indicators were estimated. Trip generation rates refer to the number of weighted trip ends per unit of the independent variable. Simply, it is a linear relationship between trip ends and the independent variable.

Data Collection

The survey sites covered all main Palestinian cities in the West Bank for sites/facilities that fit the study criteria. Other cities and towns may not have appropriate developments/facilities that fit the research purpose and criteria. One of the main challenges was locating a single use (non-mixed use) facility outside the CBD area.

Each of the identified potential facilities to be surveyed was visited to ensure that it fits the research purpose and the survey criteria. After field visits, the facilities were filtered and those to be included in the survey were selected.

The following land use categories and sub-categories were identified within the Palestinian context:

- Residential (apartment, detached, attached) use.
- Office (governmental, institutional, private) use.
- Commercial (commercial strip, large commercial store (supermarket)) use.
- School use.
- Hospital use.
- Hotel use.

The aforementioned criteria, rules and sample size considerations were applied for each category or sub-category of the surveyed land uses. These were applicable for all land use categories and sub-categories except for shopping centers where there is only one distinct shopping center in the West Bank, which is Plaza Shopping Center in Al-Bireh city. Therefore, it was not included in the analysis, although it was surveyed.

Two types of survey forms were designed for the survey work. The traffic counting form includes vehicle classes and direction of travel, as well as the time for

counting. The survey form for the development includes name of the development, location, size (square meters, number of dwelling units or apartments, number of employees or tenants, vehicle ownership, parking, public transportation,… etc.).

The actual sample size ranged from 6 to 22 depending on the type of land use and its availability. Table 1 shows a summary of sample sizes for the surveyed land uses.

Table 1. Summary of sample sizes for surveyed facilities

Land Use		Sample Size
Primary Category	**Classification**	
Residential	Apartment	15
	Detached	13
	Attached	6
Office	Governmental	19
	Institutional	7
	Private	7
Commercial	Commercial Strip	14
	Supermarket	22
School	School	14
Hospital	Hospital	11
Hotel	Hotel	8
Total Sample Size		**136**

RESULTS AND ANALYSIS

For each of the land use categories and sub-categories, the AM peak period and the PM peak period were analyzed.

Studied residential land use and its sub-categories were investigated as described before based on several independent variables, which were: number of occupied units, number of persons, gross floor area (GFA) and number of owned vehicles for both the AM and PM peak periods.

As for office land use, it was divided into governmental buildings, institutional buildings and general offices. The investigated independent variables were: number of employees, number of owned vehicles, total GFA and occupied GFA.

As for commercial land use, it was divided into commercial strips, supermarkets and shopping centers. However, only one shopping center was found that fits the site criteria; therefore, it was analyzed but not presented. The investigated independent variables were: number of employees, number of owned vehicles, total GFA and occupied GFA.

School land use includes primary and secondary as well as private and public schools for boys and girls. The investigated independent variables were: number of employees, number of students, total area and occupied GFA.

Hotel land use includes 3- to 5-star hotels. The investigated independent variables were: number of employees, number of owned vehicles, number of parking stalls, number of rooms, total area and occupied GFA.

Hospital land use includes public and private hospitals and general and specialized hospitals. The investigated independent variables were: number of employees, number of employees' owned vehicles, number of parking stalls, number of beds, total area and occupied GFA.

Tables 2 and 3 provide a summary of rates for the studied land uses and their sub-categories as well as the associated independent variables.

Expected Impact of the Research

Traffic problems can be anticipated and managed before they occur through proper transportation planning and through conducting transport impact studies for major developments; a process that is adopted by several transportation planning agencies and municipalities throughout the world as part of the procedures for obtaining the needed permits for such developments.

Based on the points mentioned above and in light of lack of policies, procedures and the basic information needed to conduct transport impact studies in Palestine, the expected impact of this research can be summarized as follows:

- The development of new policies, whether at the national or local policy levels, that introduce the need for the provision of transport impact studies, considering that the results of this study are comprehensive, as it covers all major West Bank cities and various geographic regions. In addition, the results are believed to be reliable based on sample size and statistical significance considerations.
- The technical readiness to embark on a revised process for obtaining the permits needed for major developments, considering the outputs of the study.
- The dissemination of the results, after adopting them by the relevant governmental bodies, to the main stakeholders, such as the Ministry of Local Government, the Ministry of Transportation and major municipalities, and to publicize the results and use them as part of the process of obtaining permits for major developments.
- Having local and reliable trip generation rates established for major land uses (a total of six land uses) in Palestinian cities and towns, continued efforts are encouraged to develop similar rates for the rest of land uses, such as for crafts and industrial developments, religious places, restaurants, universities, cultural centers and public parks. This effort should also be completed to develop the associated trip generation equations.
- Since trip generation is the first step in the transportation planning process, the study will play a primary role in the institutionalization of a reliable and scientific transportation planning for Palestinian cities and towns.
- The study forms the basis for creating a *"Palestinian Trip Generation Manual."*
- The study contributes to better transportation planning and anticipating critical transportation issues resulting from new major developments; therefore, mitigation process can be initiated. It also plays a role in establishing a fair "cost-sharing" mechanism by major developers who contribute to added traffic congestion created by their new developments.

Table 2. Summary of trip generation rates for the studied land uses - AM peak hour

Land Use		Sample Size	Used Variable Statistics				Rates*	Range of Rates
Category	**Sub-Category**		**Variable**	**Range**	**Mean**	**Standard Deviation**		
Residential Buildings	Apartment Buildings	15	# of Occupied Units	14-133	43.73	29.28	1.11	3.45-036
			# of Persons	70-600	226.00	143.03	0.21	0.69-0.08
			# of Owned Veh	4-72	26.00	18.08	1.86	12.08-0.67
	Detached Buildings	13	# of Occupied Units	7-220	63.46	70.75	0.98	8.88-0.28
			# of Persons	28-1060	271.38	315.44	0.23	2.22-0.06
			# of Owned Veh	9-185	67.08	52.83	0.93	6.91-0.34
	Attached Buildings	6	# of Occupied Units	13-36	22.67	7.81	1.17	2.04-0.74
			# of Persons	59-180	104.50	42.13	0.25	0.45-0.15
			# of Owned Veh	10-30	22.17	9.20	1.20	2.65-0.88
Office Buildings	Governmental Buildings	19	# of Employees	21-250	83.00	59.36	0.80	3.16-0.27
			Occupied GFA (m²)	256-3950	1367.84	1013.72	4.85	25.93-1.68
			# of Owned Veh	6-105	29.89	21.96	2.22	11.06-0.63
	Institutional Buildings	7	# of Employees	12-600	209.86	225.92	0.78	13.71-0.27
			Occupied GFA (m²)	250-12500	4003.29	4430.45	4.11	65.83-1.32
			# of Owned Veh	8-277	104.29	104.55	1.58	20.57-0.59
	Private Office Buildings	7	# of Employees	23-120	48.43	33.14	0.76	1.61-0.31
			Occupied GFA (m²)	380-2400	1209.00	618.36	3.06	9.74-1.54
			# of Owned Veh	10-45	21.14	11.33	1.75	3.70-0.82
School Buildings	Schools	14	# of Employees	15-48	29.21	8.54	7.12	13.88-4.34
			Occupied GFA (m²)	770-2550	1494.29	509.17	0.14	0.27-0.08
			# of Students	154-858	406.07	196.43	0.51	1.35-0.24
Hotel Buildings	Hotels	8	# of Employees	36-220	105.88	70.10	0.44	1.30-0.21
			Occupied GFA (m²)	4200-27000	10330.25	7173.24	0.45	1.11-0.17
			# of Rooms	41-250	146.75	71.95	0.32	1.14-0.19
Hospital Buildings	Hospitals	11	# of Employees	47-520	231.64	141.81	0.52	2.55-0.23
			Occupied GFA (m²)	1250-29000	7558.85	7969.36	1.59	9.59-0.41
			# of Beds	36-173	83.91	46.05	1.43	3.33-0.69
Commercial Buildings	Supermarkets	22	# of Employees	2-35	9.82	8.67	4.11	20.16-1.15
			Occupied GFA (m²)	110-1800	527.27	412.90	7.65	36.65-2.24
	Commercial Strips	14	# of Employees	5-37	12.57	9.46	2.72	6.83-0.92
			Occupied GFA (m²)	145-1112	400.07	322.88	8.53	23.55-3.07

*Where the GFA variable is used, the rate is per 100 m².

Table 3. Summary of trip generation rates for the studied land uses - PM peak hour

Land Use		Sample Size	Used Variable Statistics				Rates*	Range of Rages
Category	Sub-Category		Variable	Range	Mean	Standard Deviation		
Residential Buildings	Apartment Buildings	15	# of Occupied Units	14-133	43.73	29.28	0.80	2.50-0.26
			# of Persons	70-600	226.00	143.03	0.15	0.50-0.06
			# of Owned Veh	4-72	26.00	18.08	1.34	8.73-0.49
	Detached Buildings	13	# of Occupied Units	7-220	63.46	70.75	0.76	6.86-0.22
			# of Persons	28-1060	271.38	315.44	0.18	1.71-0.05
			# of Owned Veh	9-185	67.08	52.83	0.72	5.33-0.26
	Attached Buildings	6	# of Occupied Units	13-36	22.67	7.81	0.88	1.53-0.55
			# of Persons	59-180	104.50	42.13	0.19	0.34-0.11
			# of Owned Veh	10-30	22.17	9.20	0.89	1.98-0.66
Office Buildings	Governmental Buildings	19	# of Employees	21-250	83.00	59.36	0.62	2.44-0.21
			Occupied GFA (m²)	256-3950	1367.84	1013.72	3.75	20.02-1.30
			# of Owned Veh	6-105	29.89	21.96	1.71	8.54-0.49
	Institutional Buildings	7	# of Employees	12-600	209.86	225.92	0.68	11.98-0.24
			Occupied GFA (m²)	250-12500	4003.29	4430.45	3.59	5.75-1.15
			# of Owned Veh	8-277	104.29	104.55	1.38	17.96-0.52
	Private Office Buildings	7	# of Employees	23-120	48.43	33.14	0.64	1.34-0.26
			Occupied GFA (m²)	380-2400	1209.00	618.36	2.55	8.12-1.29
			# of Owned Veh	10-45	21.14	11.33	1.46	3.09-0.69
School Buildings	Schools	14	# of Employees	15-48	29.21	8.54	4.10	7.98-2.49
			Occupied GFA (m²)	770-2550	1494.29	509.17	8.01	15.55-4.69
			# of Students	154-858	406.07	196.43	0.29	0.76-0.14
Hotel Buildings	Hotels	8	# of Employees	36-220	105.88	70.10	0.46	1.36-0.22
			Occupied GFA (m²)	4200-27000	10330.25	7173.24	0.47	1.17-0.18
			# of Rooms	41-250	146.75	71.95	0.33	1.20-0.20
Hospital Buildings	Hospitals	11	# of Employees	47-520	231.64	141.81	0.46	2.25-0.20
			Occupied GFA (m²)	1250-29000	7558.85	7969.36	1.40	8.45-0.36
			# of Beds	36-173	83.91	46.05	1.26	2.93-0.61
Commercial Buildings	Supermarkets	22	# of Employees	2-35	9.82	8.67	7.84	38.48-2.20
			Occupied GFA (m²)	110-1800	527.27	412.90	14.59	69.96-4.28
	Commercial Strips	14	# of Employees	5-37	12.57	9.46	3.23	8.11-1.10
			Occupied GFA (m²)	145-1112	400.07	322.88	10.14	27.98-3.65

*Where the GFA variable is used, the rate is per 100 m².

Comparison with International Rates

The obtained trip generation rates for the study land uses were compared with those for a developed country, the USA (ITE, 2012) and a developing country in the region, the UAE (Abu Dhabi, 2012) for the common independent variables among them as shown in Table 4. It should be indicated that for cases where the land use category was further sub-classified (e.g. apartments classified by number of floors, detached houses classified by number of bedrooms, schools classified by public/private and class level,… etc.), ranges of rates were presented.

Table 4. Comparison between local, regional and international trip generation rates

Land Use Category	Sub-Category	Independent Variable	Local Trip Rate		ITE Trip Rate (1)		Abu Dhabi Rate (2)	
			AM	PM	AM	PM	AM	PM
Residential Buildings	Apartments	Per Occupied Unit	1.11	0.80	0.51	0.62	1.24 - 1.50	1.80 - 1.93
	Detached Houses		0.98	0.76	0.75	1.01	0.49 - 0.77 (per bedroom)	0.66 - 0.87 (per bedroom)
	Attached Buildings		1.17	0.88	0.66	0.83	0.23 (per bedroom)	0.29 (per bedroom)
Office Buildings	Governmental	Per Occupied GFA (100 m²)	4.85	3.75	5.46	1.12	0.78	1.44
	Institutional		4.11	3.59	1.41	1.31	1.57	1.84
	Private		3.06	2.55	1.45	1.38	2.73	1.56
Commercial Buildings	Commercial Strips	Per Occupied GFA (100 m²)	8.53	10.14	-	2.52	1.78	4.47
	Large Supermarkets		7.65	14.59	1.72	4.04	3.74	8.14
School Buildings	Schools	Per Number of Students	0.51	0.29	0.43-0.90	0.13-0.60	0.31-0.44	0.15-0.27
Hospital Buildings	Hospitals	Per Bed	1.43	1.26	1.32	1.42	1.31-1.55	0.83-3.75
Hotel Buildings	Hotels	Per Room	0.32	0.33	0.56	0.61	0.30-0.38	0.36-0.50

(1) Source: ITE (2012). Equivalent metric units are shown.

(2) Source: Abu Dhabi Road and Transit Authority (2012); Abu Dhabi city and non-CBD rates were used, as applicable.

For residential uses, trip generation rates for apartments were highest for Abu Dhabi, while detached housing rates were higher for Palestinian cities in the AM peak period and lower in the PM peak period. As for attached housing, the Palestinian rates were the highest. Rates for office and commercial land uses were generally highest in Palestinian cities. As for schools, and since range values were compared, rates were comparable among the three sources, with the ITE showing slightly higher rates. The hospital rates for

Palestinian cities were comparable with Abu Dhabi rates and lower than the ITE rates, while the Palestinian hotel rates were the lowest.

It was anticipated that land uses in Palestinian cities would generate the lowest rates among the three, since vehicle ownership rates and level of development are low compared to the other two. However, it should be recognized that the socio-economic characteristics as well as the land use characteristics among the three are different.

The household (family) size in Palestine is the highest among the three (2.54 in the USA (Statistica, 2016); 4.3 in Abu Dhabi (Colliers International, 2014); and 5.2 in the West Bank of Palestine (PCBS, 2016)). The public transportation in West Bank cities is not very efficient, particularly for areas outside the CBD where most sites were surveyed. Residents' referral to offices is relatively high. The visitation habits for patients in hospitals are more frequent and most hospitals include primary health care clinics due to shortage of primary public health services outside the hospitals. The general sizes of the facilities among the three are different, with the smallest size in Palestinian cities.

It should also be noted that higher trip generation rates, as compared to the ITE (2012), were reported by Mustafa (2016) for Palestinian cities, as well as by Naser et al. (2015) for hospitals in Amman, Jordan, which is somewhat close in its socio-economic characteristics to Palestinian cities. Both attributed this to the differences in socio-economic factors between the local population and the ITE trip generation manual case study population and recommended that this should be further verified by additional studies.

CONCLUSIONS AND RECOMMENDATIONS

This paper illustrates first the need to start proper transportation planning in Palestine. The first step in the four-step transportation planning process is trip generation. However, there are no established trip generation rates in Palestine; therefore, transportation planners may rely on trip generation rates from other countries, which are not suitable for the Palestinian environment. Moreover, conducting Transportation Impact Studies (TISs) for major developments requires first the estimation of trips generated by such developments. This research has established local trip generation rates for selected major land uses in Palestine. This will be a step towards institutionalizing transportation planning processes in the country and the preparation of the "*Palestinian Trip Generation Manual*."

The selected land uses in this study are the main and dominant land uses in Palestine: residential, office, commercial, school, hospital and hotel uses. Numerous potential sites were explored and among them, the most appropriate sites were selected based on the set criteria, which are consistent with these set by the ITE, to ensure reliable and representative results. As a result, 136 sites were surveyed. The locations of the studied sites, selected outside the CBDs, cover all main cities in the West Bank. Based on the size of the survey sites and their geographical distribution, the survey is comprehensive and produces practically reliable results. The field survey included collecting required information about the surveyed facility, in addition to counting traffic produced by each facility. The traffic counting surveys were conducted during the AM and PM peak periods for two typical workdays for each site.

The output of this research has been compared with the published values for a developed country, the USA and a developing country in the region, the UAE. It is found that the trip generation rates for the investigated land uses in Palestine have different rates (higher, comparable or lower). This can be attributed to the differences in socio-economic factors and the characteristics of the land uses among them.

The results of this research can be locally used and can facilitate the estimation of reliable generation of trips for major land uses in Palestine. The following are recommendations that will enrich the outcome of the study and open opportunities for further research:

- This study covered trip generation by a single land use; however, major development projects include

multiple uses within the development site. Therefore, further research should cover the trip generation of multi-use developments and capture the internal trips within the development.

- It is common for certain land uses, such as commercial developments, to have "pass-by" trips. These are trips attracted to the development by pass-by travelers; therefore, these are not new trips on the road. Further research should study the impact of pass-by trips on trip generation rates produced by this study for selected land uses.
- The results of this study are valuable and should be disseminated to the relevant stakeholders such as the Ministry of Local Government, Ministry of Transport and the municipalities.
- Considering the results of this study, it is proposed to start conducting the first step to initiate urban transportation planning processes in Palestine, which is trip generation. It is also essential to use the research results for conducting TISs. Proper promotion should be instituted for the adoption of TISs as part of the permitting process at the municipal level for major developments. In addition, there should be policies to determine the various TIS levels based on the size of development under consideration.
- This study is the first of its kind in Palestine. Although it is comprehensive in terms of size and geographic distribution, similar surveys should be continued to cover additional sample size for the studied land uses to achieve higher accuracy and reliability. Other major land uses should be investigated; for example, universities, religious, cultural and touristic/recreational land uses, as well as craft and industrial land uses.

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