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Traffic Impact of Planned Gaza Seaport on Major Roads in Gaza Strip, Palestine

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Abstract—the establishment of a commercial seaport in Gaza Strip, Palestine is a strategic national project that has several implications on different aspects of life. The aim of this research is to study the impact of establishing the Gaza commercial seaport on the roadway network in the Gaza Strip. Data was collected on the main roads and TransCAD program has been utilized as a research tool. The results showed that the traffic morning peak occurs between 7:00 to 10:00, and that the average Peak Hour Factor is 0.91. The heaviest peak hour traffic flow was 20,915 vehicles/hr. This was recorded at the intersection of Jalaa and Omar al-Mukhtar streets, known as the Saraya Intersection. The results also showed that traffic in the areas near the seaport is expected to be mostly affected by the seaport construction. The traffic flow at the intersection of Al-Rasheed and Al-Hurreya Streets (known as Netzareem Intersection) is estimated to increase by more than 10%; however, no effect is expected on traffic flow at the Saraya Intersection. The total vehicle hours of travel on the network (VHT), was 19,981 vehicle hours in 2015 and has been estimated at 23,729 vehicle hours in 2020 without the presence of the port. The latter figure is expected to reach 32,635 vehicle hours in 2020 if the port is constructed. It is recommended to redesign Gaza Seaport with larger capacity and to expedite its construction in order to respond to the increasing local demand of goods considering that the seaport has been found to have a limited effect on the traffic network in the Gaza Strip.

Index Terms—seaport, Gaza Strip, Palestine, traffic impact.

I INTRODUCTION

The transportation system in Gaza Strip currently consists of only road transport. The Gaza strip has a limited and poorly developed road network. The road network consists of 76 km of main roads, 122 km of regional roads and 99 km of local roads (PCBS, 2010).

Transportation planning relies on travel demand forecasting which involves predicting the number of vehicles or travelers that will use a particular transportation facility in the future (Almasri, Sarraj, & El Jamassi, 2010).

II BACKGROUND

Before 1967, there used to exist a single railway line running from north to south along the center of Gaza Strip. Nowadays, the railway track is deserted and in disrepair, and little parts of the rack remains. Gaza strip had a small airport to the east of Rafah Governorate; however, it was destroyed by the (Israeli) occupation forces in 2001. At the start of the Palestinian National Authority (PNA), a small seaport has been built which is only used by fishermen. Since the time of building this seaport, it was not allowed for foreign ships to dock at the seaport (Almasri, 2012). Figure 1 shows a map of Gaza Strip indicating the proposed site of the seaport.

The Gaza Strip is suffering from strict siege by land, sea and air. This siege was imposed by the (Israeli) occupation on Gaza Strip after the legislative elections in 2006. (Israel) then reinforced the blockade in June 2007. The siege includes closing all borders between Gaza Strip and both Egypt and (Israel); and preventing cement, gravel, fuel and many other commodities from entering Gaza Strip. Another aspect of the siege is restricting fishing area in the sea. Palestinian National Authority (PNA) has worked hard to create a seaport south of Gaza City, which is considered as one of the most important strategic projects in Palestine; politically and economically. The political importance of this project is embedded in establishing the concept of the rule of the Palestinian State on the international territorial water. The project also works to determine the dimensions of the territorial waters and the right of the Palestinian State in the areas of international water and in exploration of natural resources. In July 2014, the (Israeli) occupation launched a new, cruel and devastating aggression on the Gaza Strip, which lasted for 50 days. The most important Palestinian demands in the ceasefire negotiations were lifting the siege and establishing a commercial seaport. The aim of the Palestinians of establishing this seaport is to provide a free crossing from Palestine to the outside world, which would improve the economic situation. This is because the construction of the commercial seaport is considered by the Palestinians as one of other important steps to connect the local economy with the global economy. It also helps expanding international trade and developing exports, local industries and business services. This, in turn, would work to increase the GDP and to raise the level of income in addition to the creation of many permanent jobs.

Figure 1: Gaza Strip Map (adown.tk/gaza-strip-map, Accessed April 2017)

The Gaza commercial seaport has many expected positive effects on the Palestinian economy; however, the establishment of the new commercial seaport should be based on scientific and careful planning. Furthermore, the effects resulting from the establishment of the seaport on different sectors must be studied. One of the most important sectors is transportation, which is the subject of study of this research.

III Gaza seaport

The The Palestinian National Authority (PNA) has a plan to develop a new deep-water port in Gaza, just south of Gaza city. It expects that direct access to the port will enable the economy of Gaza, as well as that of the west Bank, to expand, diversify its foreign trade, and foster growth in export-oriented industries and trade related services. Growth in eternal trade-oriented industries and services will in turn entail growth in domestic output and incomes and create new and sustained employment opportunities. A further important benefit will be lower transportation costs for Palestinian imports and exports (Parsons Brinkerhoff International, Inc. , 2001).

Landside uses related to port development and operations include direct and indirect industrial activities and the transportation system needed to support them.

The Palestinian Authority, in its Regional Plan for Gaza Governorates, Volume II, December, 1997, states that the Authority plans to establish a "Harbour Free Trade and Export Processing Zone" of 1,700 donums next to the port, which will be designed to handle heavy products for shipment. In addition, plans are to establish several industrial areas throughout Gaza that will absorb new industrial investment and provide sites for relocating some existing industries. (Parsons Brinkerhoff International, Inc. , 2001). The Ministry of Planning reaffairmed that it is necessary to develop and rehabilitate the current road network in Gaza Strip and to re-operate the airport and to construct the seaport as soon as possible (Ministry of Planning, 2006). The Euro-Mid Observer in its report on Gaza Seaport stated that "Amidst the chronic crisis, the most effective long-term solution has been ignored: reopen Gaza's seaport routes to the outside world" (Euro-Mid Observer, 2014).

IV Methodology

The main objective of this research is to study the effect of establishing a new commercial seaport in Gaza Strip on traffic flow. The methodology of this research is based on the travel demand forecasting approach, as it is a major step involved in transportation planning. Data including information required for modelling the network such as the characteristics of links and zones was collected. Link characteristics such as name, classification, length, free flow speed, travel time, direction and capacity were collected. Zone characteristics comprise size, boundaries, centroids and connecters to the links.

For the purpose of analysis of the existing situation, traffic counts at 79 locations on selected main roads were conducted. These locations were carefully selected to be as close as possible the the main 22 road intersections in Gaza Strip. Traffic counts were performed on 25/10/2015 for three hours from 7:00 am to 10:00 am with the assistance of civil engineering students.The research was carried out in five stages:

First Stage (Network Building): Gaza Strip was divided into Traffic Analysis Zones (TAZ) in order to build the network.

Second Stage (Base Year O-D Estimation): In this stage, O-D matrix table was estimated based on traffic volume counts collected at the major road intersections in the base year.

Third Stage (Future OD Estimation): Future vehicular attraction at Gaza Seaport was forecasted using Cargo forecasting in the Gaza seaport and ITE trip generation manual.

Fourth Stage (Estimating Traffic generated by Seaport): The impact of Gaza Seaport on traffic demand and highway network in Gaza Strip was determined.

Fifth Stage (Traffic Flow Assignment): The final step in the transportation forecasting process was to determine the actual street and highway routes that will be used and the number of vehicles that are expected on each highway segment.

For more details about the methodology and the mathematical approach reference could me made to Master thesis entitled Traffic Impact of Planned Gaza Seaport on Major Road in Gaza Strip (Abu Zarifa, 2016).

V Results and Analysis

A Network Building

The network building is very important to determine the traffic assignment. The first step of network building is determining the streets in the study area. The second step is to input the required data for building OD matrix. There are two kinds of data: the first type is traffic data (traffic flow, and speed) and the second one is geometric data (direction, time, and capacity).

Traffic flow was calculated on 79 different roads (links) making use of traffic flow counts at 22 main road intersections in Gaza Strip. Al-Saraya Intersection has the highest traffic flow of 7,615 vehicles per hour; this is because Al-Saraya Intersection is located at the heart of a commercial center in Gaza City. AL-Rasheed Street Intersection with Khan Younis entrance has the lowest traffic flow of 399 vehicles per hour during the peak period.

B Base Year O-D Estimation

O-D matrix estimation from traffic counts is preferred because of the lack of data on the socioeconomic characteristics of people living in Gaza Strip. In order to find out the number of trips, O-D matrix method is used. This method depends on traffic counts and geometric streets data such as capacity and travel time. It was not possible to use a trip generation or a trip distribution model. The reason for that was as explained by Dar Al Handasa report as they stated: “However, developing countries usually suffer from the lack of socioeconomic and land use data in addition to the expected growth factor. Thus, estimates of the rate of growth in vehicle ownership can be estimated by direct projection of their historical data” (DAR Al Handasa, 1999).

C Future O-D Estimation

After the establishment of the Palestinian National Authority in 1994, Dr. Sarraj in a study on the behavior of road users in Gaza, Palestine, stated “statistics show that there was a very sharp and sudden increase of more than 20% in the number of registered vehicles in the Gaza Strip between 1993 and 1994. In 1995 the increase in the number of registered vehicles was even greater; it was about 35%” (Sarraj, 2001).

Based on data published by the Palestinian Central Bureau of Statistics about the number of rergistered vehicles in Gaza Strip between 1970 and 2014 (PCBS, 2014), the annual growth rate of the number of registered motor vehicles in Gaza Strip was almost constant in the period 1970-1985, and highly fluctuating between the years 1985 and 1995. However, it seems to be almost steady during the last few years. For the benefit of this research, the average growth rate for the past fifteen years starting from 1999 to 2014 was calculated as 3.1% and was used to determine the predicted number of vehicles in the future.

D Estimating Additional Traffic Due To New Seaport

To assess the impact of sensitive and important new facilities in the area, a study should be conducted on the private sector facilities in the region that may be affected as a result of the creation of this new facility. In order to calculate the number of trips that are attracted to the port there are two methods:

1. *ITE trip generation manual method*

This method depends on the number of berths in the Seaport. The berth is a place in which a vessel is moored or secured; place alongside a quay where a ship loads or discharges cargo. The number of berths in Gaza Seaport is different in each construction phase as shown in Table 1. The ITE Trip Generation Manual suggests the use the following equation for a water port/marine terminal (ITE, 2012):

$$\text{Trips/day} = 172 \times \text{number of berths}$$

The number of trips per hour can be estimated by dividing the total number of trips per day by the number of working hours. It was assumed that the Gaza Seaport works just for 6 hours per day, since the official daily working time for

TABLE 1
Number of Berths and Trips in each phase
***Source:* (Smaling, Velsink, Groenveld, & Booy, 1996)**.

Construction Phase	Phase I	Phase II	Phase III
No. of Berths	3	4	7
Trips/day	516	686	1201
Trips/hr	86	114	200

civil servants in Gaza is from 8 A.M. to 2 P.M. Therefore, the following equation was used.

Trips/hour = (Trips/day)/6

The trips in this method include all trips (trucks and passenger cars) attracted by Gaza Seaport.

shows the number of all trips per hour that are expected in each phase after the construction of Gaza Seaport in 2020. It was not possible to deal separately with public transportation. This is simply because it is included in the figures in Table 3 and this service is not well developed at the local level. The mostly used public transportation service in Gaza is the shared taxi service.

E Traffic Flow Assignment Stage

The first result is the O-D matrix. This is considered as the most essential input for the current and future traffic prediction when assigned to the network. The traffic assignment process should have a prior accurate O-D matrix. The last and the most important performance measure is the volume overcapacity ratio (VOC), which is calculated for each line in the network. Figure 2 presents the max VOC map for Gaza Strip in the base year 2015.

TABLE 2
Import and Export Forecasts at Gaza Seaport and Trips in Each Phase
Source: Thesis of D. Smaling, (Smaling, Velsink, Groenveld, & Booy, 1996)

Construction Phase		Phase I	Phase II	Phase III
Containers	Full (TEU)[1]	10,991	42,500	175,000
	Empty (TEU)	3,428	6,428	25,000
General cargo (t)		215,300	340,000	1,400,000
Dry bulk	Grain (t)	92,000	115,000	350,000
	Marble (t)	100,000	100,000	100,000
Liquid bulk (t)		366,000	970,000	2,000,000
Total (t)		905,192	2,035,000	5,950,000
Trips (Truck 30t)/year		30,173	67,833	198,333
Trips (Truck 30t)/day		96	217	634
Trips (Truck 30t)/hr		16	36	106

Note: 1 TEU = 12 ton

2. *Average Trucks Load Method*

This method depends on the maximum number of tons of the import and export forecasts at the Seaport. The generated trips in this method are just truck trips. The maximum of the import and export forecasts in Gaza Seaport are different at each phase. To estimate the number of Trips, it was assumed that the average truckload is 30 tons, which is the average loading capacity of the trucks that enter Gaza through Karm Abu Salem Crossing. Table 2 presents an estimation of import and export forecasts in each phase of construction as suggested by Smaling (Smaling, Velsink, Groenveld, & Booy, 1996).

As could be noticed, ITE method considers all trips that will be generated because of the construction of the Gaza seaport. This includes cars and trucks. However, the Average Trucks Load Method only considers the resulting trips by trucks. Thus, this study will adopt the first method. Table 3

TransCAD usually estimates the traffic volumes for each link in the traffic network. This process needs an O-D matrix (the estimated one), and a line network layer with its attributes. The Stochastic User Equilibrium method was selected to perform traffic assignment because it gives results that are more realistic. More details may be obtaind from a study entitled “Network capacity with probit-based stochastic user equilibrium problem” (Lu L, 2017). Figure 3 shows the es-

TABLE 3
Number of trips per hour for Gaza Seaport**.**

Phases of Gaza Seaport	trip/hr
phase I	86
phase II	114
phase III	200

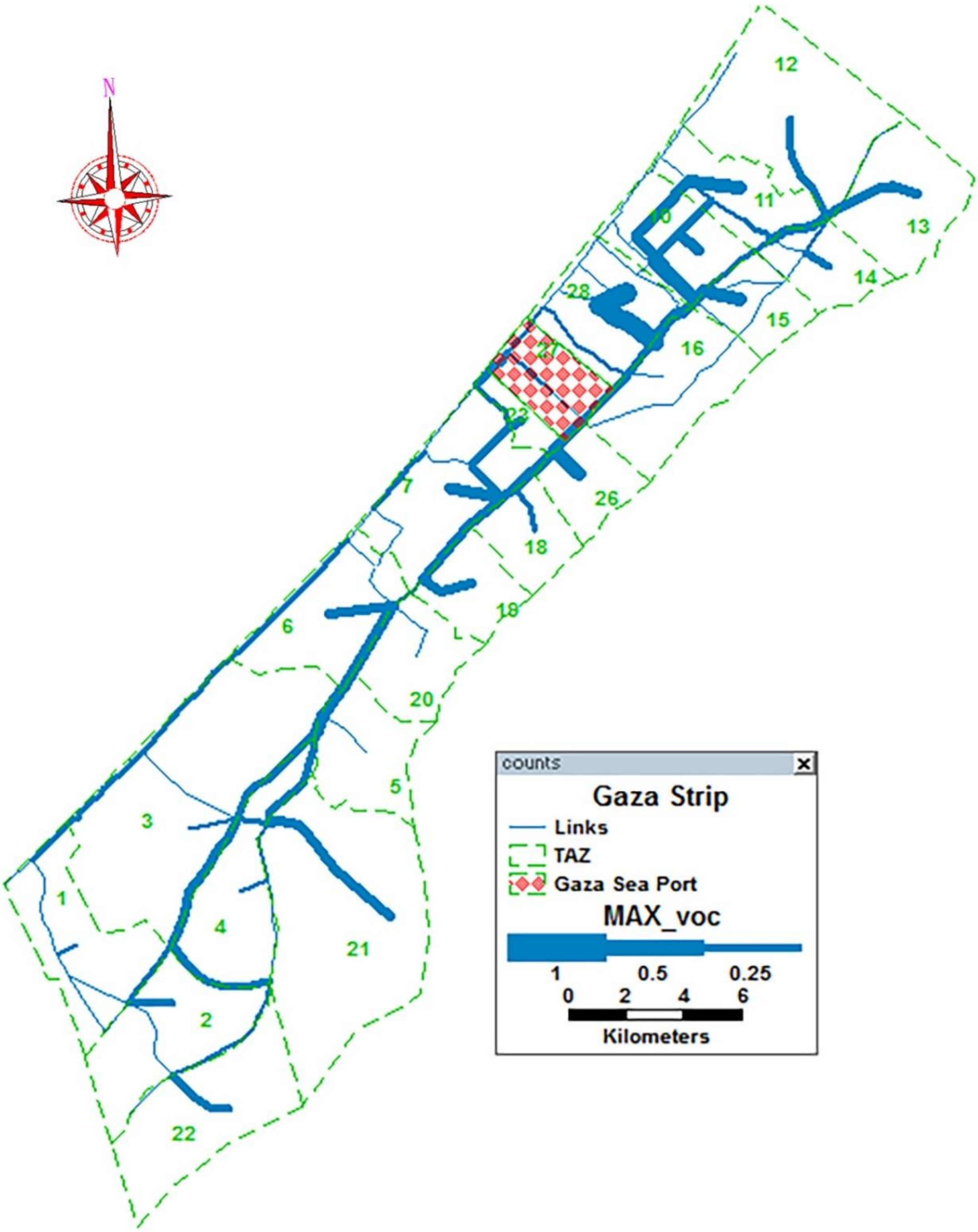

Figure 2: Max Volume over Capacity (VOC) in Gaza Strip for 2015

timated Total traffic flow in 2015 on each link represented by line width.

According to the analysis of the available data described previously, the estimation of the future O-D Matrix was based on the average growth rate of vehicles in Gaza Strip, which is 3.1 %. Therefore, the future O-D matrix in 2020 can be obtained by applying this growth rate to each current (2015) O-D matrix cell.

It is well known that the future O-D Estimations is obtained in the Future Demand O-D Matrix by multiplying base-year O-D matrix with an expected growth in trips as shown in this Equation (O'Flaherty C.A., 1997).

$$T_{ijf} = T_{ijP} \times G_{Pf} \quad \textbf{(7)}$$

Where:

T_{ijf} = trips for O-D pair ij in future year f;
T_{ijP} = trips for O-D pair ij in present year p;
G_{Pf}= expected growth in trips between year f and p.

The study period that was considered for forecast was 5

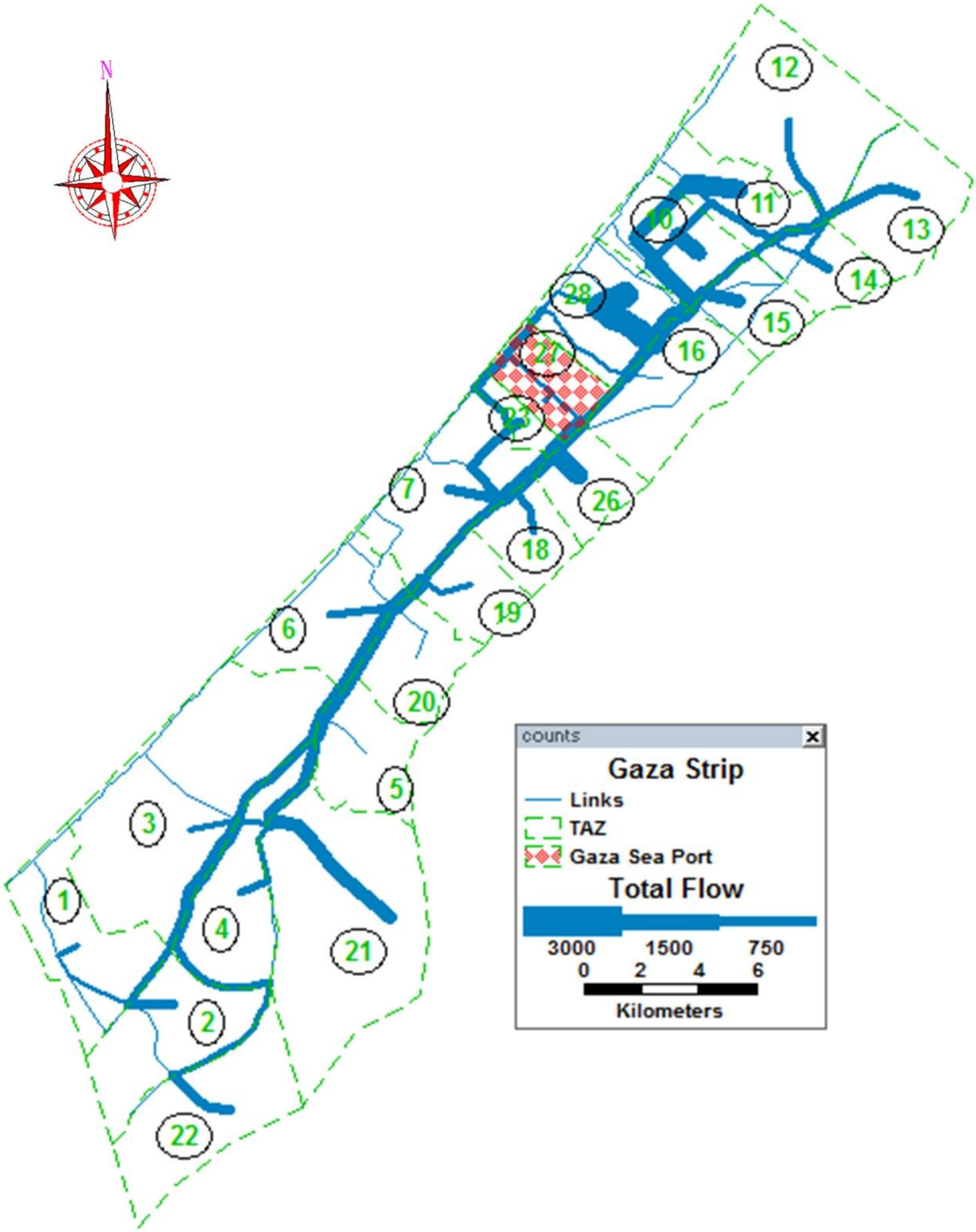

Figure 3: Total Estimated Traffic Flows in 2015

years from the year 2015 to the year 2020. This is because Gaza Seaport construction is expected to take about 3.5 to 5 years according to the seaport report by the Ministry of Transportation (Ministry of Transportation, 2005).

In Table 4, the difference between total flow in the future year 2020 without Gaza Seaport and total flow with Gaza Seaport at the main intersections is presented. Intersections located far from Gaza Seaport are not expected to be heavily affected by the construction of the Gaza Seaport. These intersections include AlSaraya and Dolah Intersections. At these intersections, the difference between the future traffic flow in 2020 with the seaport and without it was close to zero. However, the intersections near the port were heavily affected such as Netzareem Intersection, with 10.18% increase, and AlZahra intersection, with 14.3% increase. As road intersections get far from the Gaza Seaport the impact on them gets less and less, and vice versa. The impact of the Construction of Gaza Seaport on Major intersections in Gaza Strip is graphically presented in Figure 4.

TABLE 4

The estimated traffic flow in 2020 with and without the construction of the Gaza Seaport.

ID	Intersection Name	Total Flow future year 2020 Without Seaport	Total Flow future year 2020 With Seaport	Change in Traffic Flow (%)
2	Salah al-Din intersection with AL-Quads (Zemo)	3739	3818	2.11
5	Salah al-Din intersection with AL-Wahada and Omar AL mokhtar (AL Shejaiya)	7110	7406	4.16
6	Omar AL mokhtar intersection with AL Jalal (AL Saraya)	10161	10161	0.00
9	Salah al-Din intersection with Number "8" (Dolah)	6879	6879	0.00
11	Salah al-Din intersection with AL Karama (Netzsareem)	3913	4311	10.18
13	Salah al-Din intersection with AL Nuseirat	6218	6671	6.42
15	Salah al-Din intersection with Deir AL Balah	2443	2559	4.77
17	Salah al-Din intersection with Abasan (BaniSuhaila)	4502	5688	1.67
18	Salah al-Din intersection with Taha Hussein (Khrbat AL Adas)	1736	1753	0.95
22	AL-Rasheed intersection with AL Palestine (AL Zahra)	2323	2655	14.30
23	Al-Rasheed intersection with the Nuseirat	495	528	6.65
24	AL-Rasheed intersection with Akeala	495	528	6.65
25	AL-Rasheed intersection with Khan Younis	572	605	5.75

VI Conclusions and Recommendations

Traffic counts have been carried out by IUG civil engineering students from 7 to 10 A.M. at 22 locations near main intersections distributed over Gaza Strip.

Traffic counts analysis showed that the greatest traffic flow was recorded in Gaza city namely close to the intersection of Al Jalaa Street with Omar Al Mukhtar Street. Traffic volume in both directions in the vicinity of this intersection was 20,915 Vehicle /3 hours, and 7,615 vehicle/hr. in the peak hour. This is followed by the intersection of Al Jalaa Street with Jamal Abdul Nasser Street. Traffic volume in both directions at this intersection was 18,062 Vehicle/3 hrs, and 6,656 Vehicle/ hr. in the peak hour.

The peak-hour-factor values ranged from 0.98 to 0.77, and the average value for the network flow was 0.91.

The average percentage of passenger cars in Gaza Strip traffic composition was 79%, while the percentage of trucks was 6.5% and the remaining other vehicle types was 14.5%.

The future estimation of O-D Matrix was based on the average growth rate of registered vehicles in Gaza Strip, which is 3.1%. The future O-D matrix in 2020 was obtained by applying the growth rate factor to each cell in the current (2015) O-D matrix.

The impact of the establishment of Gaza Seaport was found to be concentrated on the nearby main roads in the Gaza Strip. This impact is reduced as the distance increases between these intersections and the seaport. The most significant impact is expected to be at the following intersections: Netzareem intersection, Al- Zahra Entrance on Al-Rasheed Road, as well as Deir Al-Balah Entrance on Al-Rasheed Road.

The total hours of travel (VHT) on the network, was 19,981 vehicle hours in 2015 and has been estimated at 23,729 vehicle hours in 2020 without the presence of the port. This shows an increase of 18.7%. The latter figure is expected to reach 32,635 vehicle hours in 2020 if the port is constructed. This shows an increase of more than 37% in total hours of travel.

The following actions are recommended:

It is recommended to carry out further studies to cover the afternoon traffic activity.

To increase the number of roads included in the network analysis, as well as the number of traffic counting nodes to cover more areas of Gaza Strip.

To update traffic counting and traffic network data every 3-5 years in order to help traffic planning and decision making in Gaza Strip.

To carry out further studies in order to investigate the impact of other strategic facilities on traffic such as Arafat (Gaza) International Airport.

To construct a bridge above the intersection of Salah Al Deen and Al Karama Streets (Netzareem Intersection) in order to serve the increasing traffic flow at this intersection especially after the construction of Gaza Seaport. This is because this intersection is planned to be the main entrance

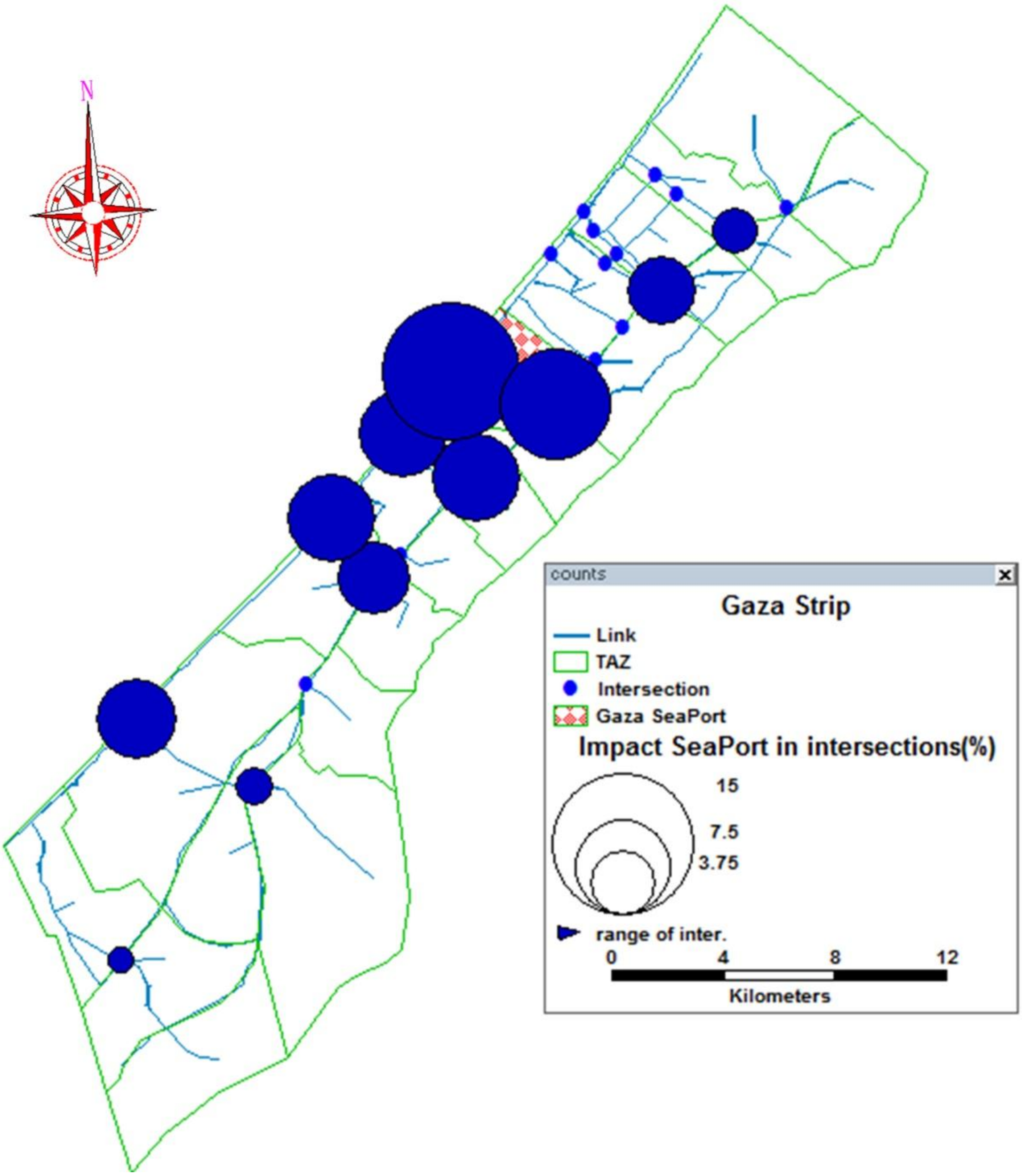

Figure 4: Impact of Gaza Seaport Construction on Major intersections in Gaza Strip

of the seaport by the Ministry of Transportation (2015).

It is essential to develop the main roads, which are expected to play a main role in the transport of goods to and from the seaport, which are Al-Karama, Al-Rasheed, and Salah Al-Din Streets.

Finally, it is recommended to redesign Gaza Seaport with larger capacity and to expedite its construction in order to respond to the increasing demand of goods considering that the seaport has been found to have a limited effect on the traffic network in the Gaza Strip.

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