GIS Approach to Study the Impact of Suez Canal Proposed Tunnels on Transportation activity for Sinai Region

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ABSTRACT

A GIS approach is applied in the current study to investigate the effect of tunnel(s) construction across Suez Canalin order to facilitate linkage of Sinai region to delta region. In the developed GISapproach, The selected tunnels locations are considered as a passage gates for the various transportation trip flow coming from the eastern part of the delta zone. The focus in the current study is to attempt to measure the positive effect of tunnel(s) existence on the various trip distances originating from delta zone towards different destination(s) within Sinai. The details for development of such a GIS approach is explained thoroughly in the course of the study. In order to measure the ease of trip flow to the other side of the canal, a scenario of Before / After is adopted through the network analyzer module. Also the combined effect of tunnel(s) scenario is conducted where certain activation order is adopted. The research results were presented in a normalized trip distance relationship in order to facilitate reading the tunnel existence effect .

Keywords: Networks linkage, trip two ends selection, Before / After Scenario, search for minimum path route, trip length equal line, tunnel(s) activation.

INTRODUCTION

The triangular Sinai Peninsula is located in a strategic space in the international balancing map since the begging of time. The total area of Sinai Peninsula is about 61,000 km² which is nearly 6% of Egypt's total area & considered the concourse of the two continents: The African and Asian continents, and the land bridge which connects the two of them as from the beginning of dawn. Shaped as a triangle, its northern base is located at the Mediterranean Sea (from Port Said at east to Rafah at west) along 200 km. and the head is located in south at Ras Mohammed, which is 390 km off the Mediterranean. The western extension of Sinai triangle is about 510 km including Suez Canal & bay, while the eastern

Figure 1:GeneralSinai Peninsula location

extension is about 455 km including Al-Aqaba bay and Egypt's political borders as shown in figure [1].

The interest in developing the highway, communication and transportation sections started just after the liberation of Sinai to provide overland connections to the eastern world. In 1993-1994 the longest paved road in Sinai was extended to 6000 km in addition to another 1140 km. There are many unpaved roads. The leading roads are: Al-Kantara road east of Rafah, Ismailia highway at the border line of Egypt at Al-Awga, Al-Shat highway at Ras Al-Nakb. In addition to Al-kantara way east of Al-Shat (Sharm El-Sheikh), Sharm El-Sheikh-Taba way, Nweba-Rafah way, Be'r Al-Abd Sadr el hetan way, Nweba-catherine through Veran valley as illustrated in figure [2].

Figure 2. General Sinai Isolated Highway Network

Transportation is very significant for a nation's development. It is essential for a nation's development and growth. It has consumed a considerable portion of its time and resources. The human needs many hours per day in transportation. The essential requirement for transportation is economic; the person needs transportation for several objectives such as travel in search of food, work, trade, exploration, or for many other things.

Applying the principles and applications of geographic information systems technologies to transportation problems is referred to as Geographic Information Systems for Transportation (GIS–T) [1]. A GIS–T research can be approached from two different, but complementary, directions. While some GIS-T researches focuses on issues of "How can we further develop and enhance the GIS design in order to meet the needs of transportation application?" other GIS-T researches investigates the questions of "How can we use GIS to facilitate and improve transportation studies?" [2], [3].

During the past years, several GIS-T , applications have been conducted in the Construction & Building Engineering Department, Arab Academy for Science & Technology & Maritime Transport. These attempts varies in its scope, the details of the previous work in the field of GIS-T are listed in reference [4] through [13].

Scope of the Present Study

The Sinai Highway network is currently linked with the rest of Egypt through only two locations , The Salam Bridge and the Ahmad Hamdy tunnel , which of course hinders the development process for the Sinai region . The present study addresses the possibility of increasing the linkage points through additional tunnels construction . What could be the future performane of the highway network on both sides of the canal ? . As it is expected , the direct impact on various transportation activity from and to Sinai region will be positive . Is it possible to **MEASURE** such an effect of tunnel costruction . ? Also , Is it possible to determine the relative impact in case of availability of many tunnels . ?

The present research work seeks a suitable tool to enable us to investigate properly the existence of these additional tunnels from a transportation point of view.

As the geographic information system proved its capability in handling different transportation problems as stated earlier from the author's previous

Figure 3:New Suggested Canal Connection Points

work, it has been chosen to formulate the present GIS system to tackle the current analysis problem.
In the current study, four locations are chosen to construct new tunnels along the sues canal length as follows:

- South of port said by 19km [Port Said tunnel].
- South of Salam bridge by 23 km [Ismailia 1tunnel].
- South of Salam bridge by 47 km [Ismailia 2 tunnel].
- North of Suez city by 11 km [Suez tunnel].

Thus, the total canal length is divided accordingly as shown by figure [3].

Data Collection, Digitizing & Working in GIS Environment

Development of the current GIS approach required certain preparation steps in order to be ready for the analysis stage which forms the core of the present study. The sequence of the building stages will be briefly outlined in the following sections.

Google Earth Usage for Terrain Projection

In this part, A suitable elevation in the Google Earth Environment was selected to let the terrain of the studied region [Sinai region & Eastern part of Delta region] clear enough to demonstrates the details of the available highway network. Rectangular Images with 20 * 10 km were selected to cover the entire studied area on both sides of the sues canal. These images were transferred to the GIS Arc View environment to formulate the bases for the analysis process as shown in figure [4].

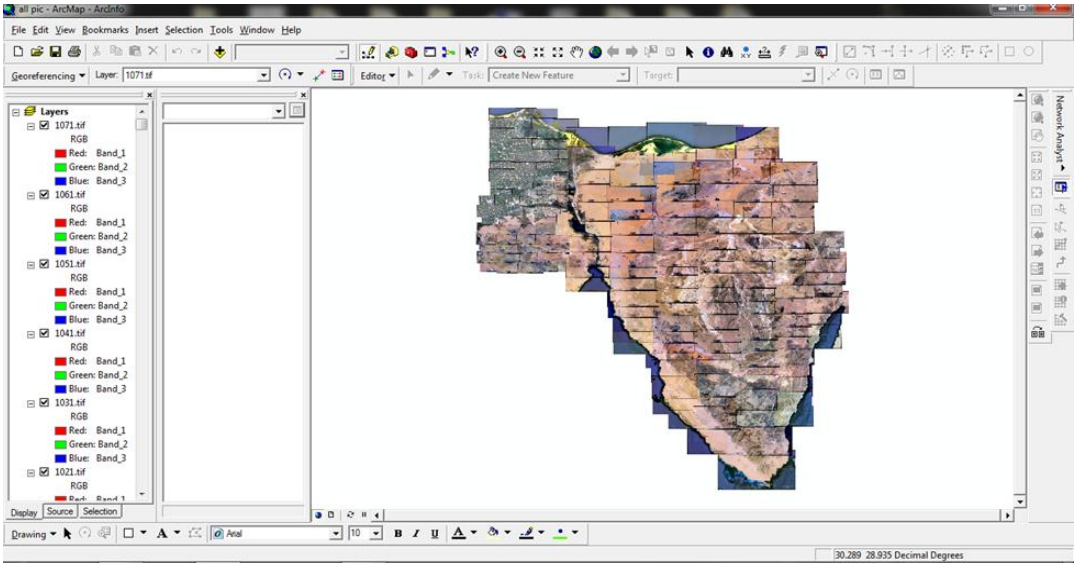


Figure 4: All covered pictures after transferred to ARCGIS

Digitizing Process and Forming the Corresponding Themes

In this part, A detailed formations of the poly lines layers and nodes layer were conducted through a careful digitizing process. Figure [5] shows the overall digitized highway network for the present study. It should be mentioned that for the poly lines layers and in order to achieve the objective of the study, two separate themes were constructed in order for the network analyzer to select the minimum path route in the two studied cases. The first scenario **Before** construction of the tunnels(s) [Al Salam bridge & Ahmed hamdy tunnel ONLY], the second scenario **After** tunnel(s) construction [with tunnel(s) activation order] in order to be able to measure the impact of tunnel(s) existence.

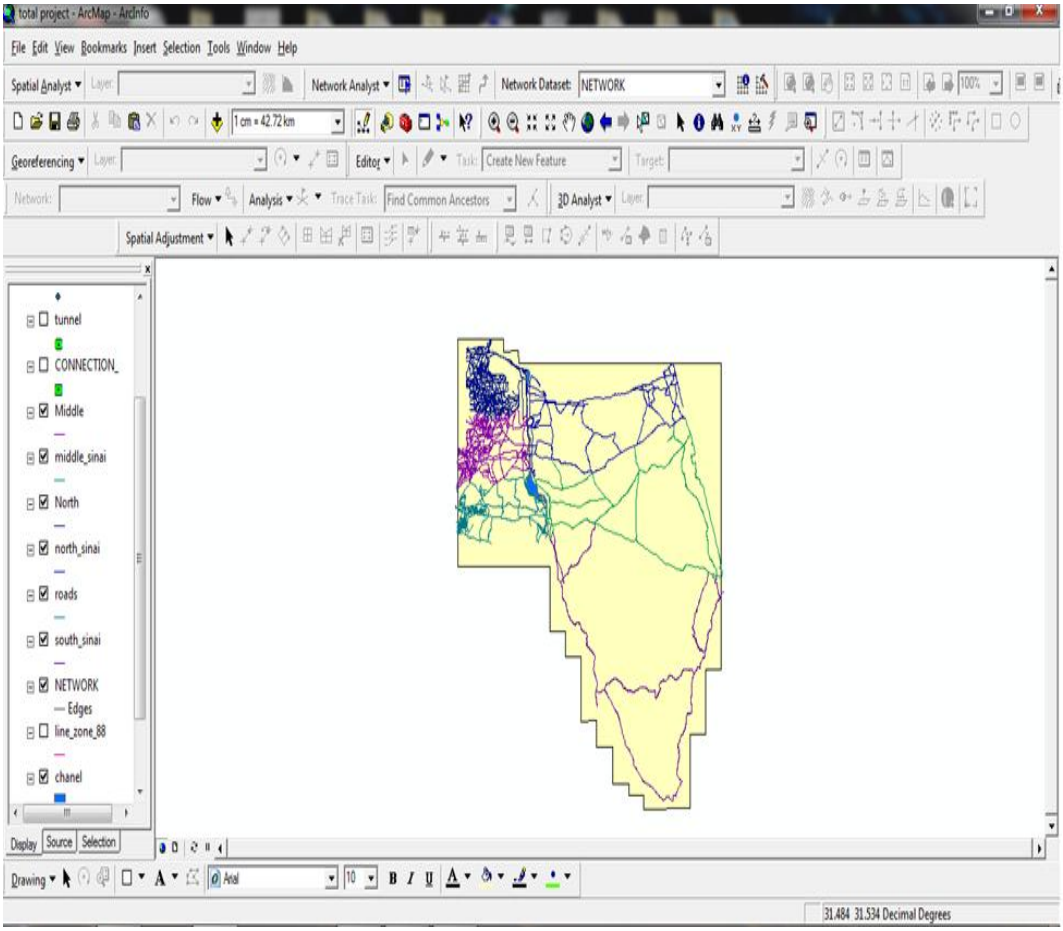
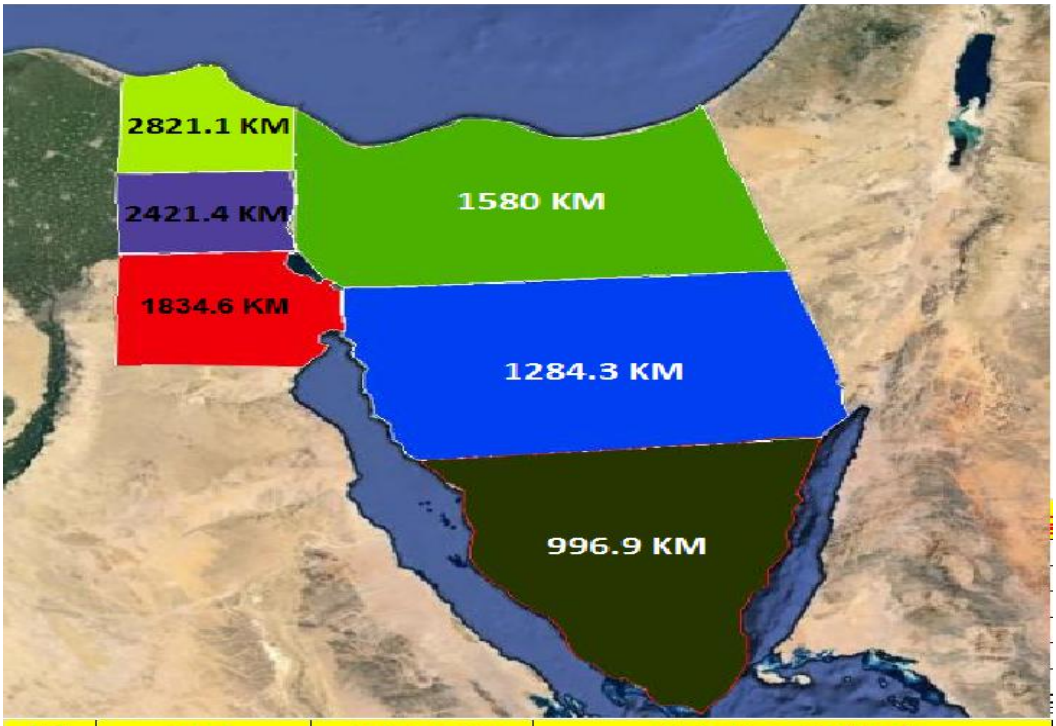


Figure 5: Highway Network extracted layer

Selecting the TWO ends of the Transportation TRIP(s)

At this stage, and after setting the proper platform for the analysis process, the different trip nodes were selected. The entire region of the analysis was divided into six zones, three on the western side of the canal [Port said, Ismailia &Suez], and three on the eastern side of the canal [the national future view is to deal with Sinai in three separate governorates, North Sinai, Middle Sinai and South Sinai] . The direction of trips adopted in the present analysis is from the west to the east, and five trip origin(s) were selected for each zone on the western side. 43 trip ends [destinations] were selected for the Sinai region, 16 for North Sinai, 13 for middle Sinai & 14 for South Sinai. Figure [6] illustrates the accumulated length of the digitized highway for each of the studied zones. Figure [7] shows the selected nodes for both sides of the canal which represent the entire region covered in the analysis and the origin/destination nodes inside each zone.



NO	zone	total path	total length (km)	
1	NORTH SINAI	163	1580.0	
2	MADDLE SINAI	42	1284.3	3861.2
3	SOUTH SINAI	20	996.9	
4	Northwest Channel	991	2821.1	
5	MADDLEWest Channel	841	2421.4	7077.2
6	SOUTH West Channel	1186	1834.6	
TOTAL		2057	10938.3	

Figure 6: Total length of roads in studying area

GIS Network Analyzer Minimum Trip Distance Search

This part can be considered as the core of the current analysis where the measure of the tunnel impact on the various transportation activities can be evaluated. The comparison of the adopted concept of Before / After is based on the trip distance(s) from certain Origin to certain destination. Therefore, the network analyzer for each specific trip was searching for the minimum trip length twice. One theme where the tunnel(s) don't exist and the only passage to the other side is through Al Salam Bridge & Ahmad Hamdy tunnel. The other theme , where the four suggested tunnels are there and easing the flow to Sinai region. The comparison is presented in the following section where it was plotted in a Normalized relationship which makes it more readable. The total number of analysis segments conducted was nine, where, each specific zone on the western side was propagating trips to each of the three Sinai Zones. Finally, for each trip origin on the western side, a total of 43 trips were studied using the concept of

Before/After. Figure [8] shows a sample of the sequence adopted in the analysis, where the Northern western zone is propagating various trips to the three zones of Sinai separately.

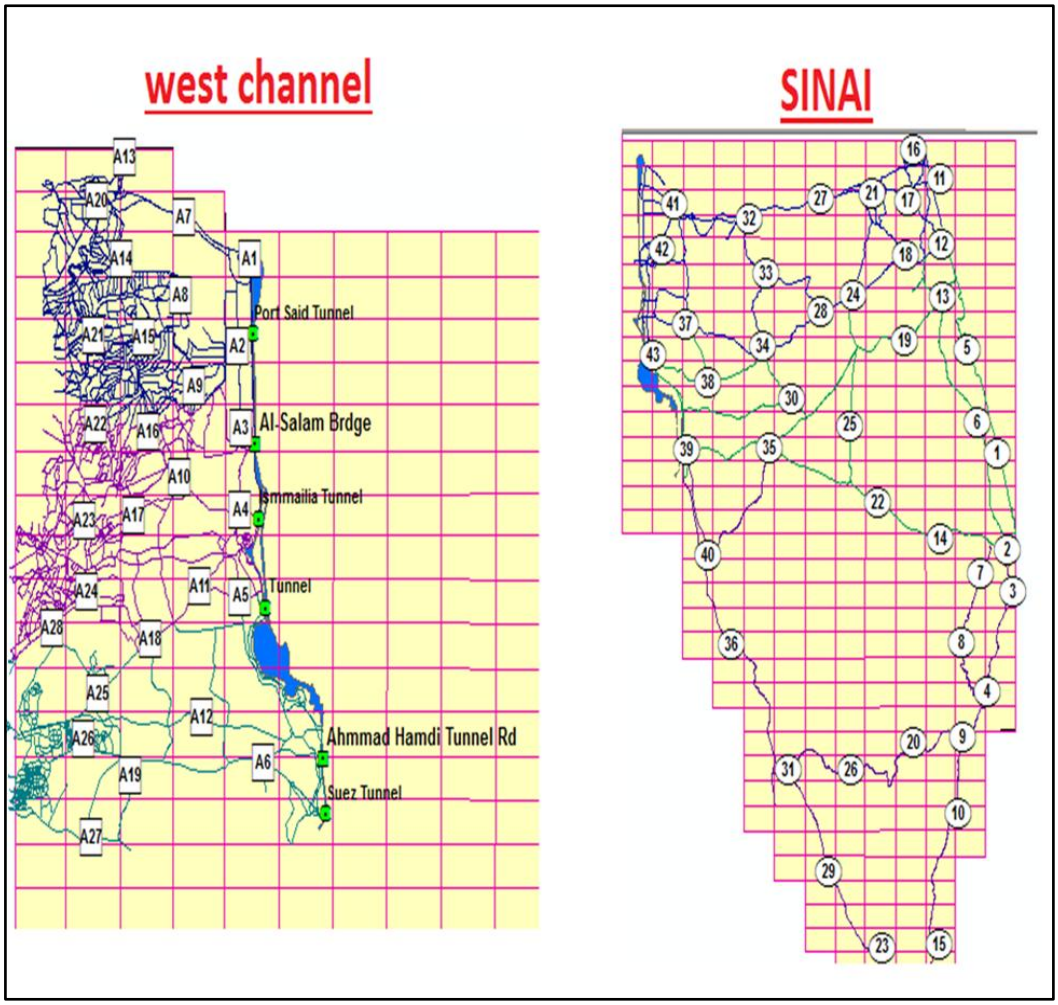


Figure 7:Selected Origin/Destination Nodes for all studied zones

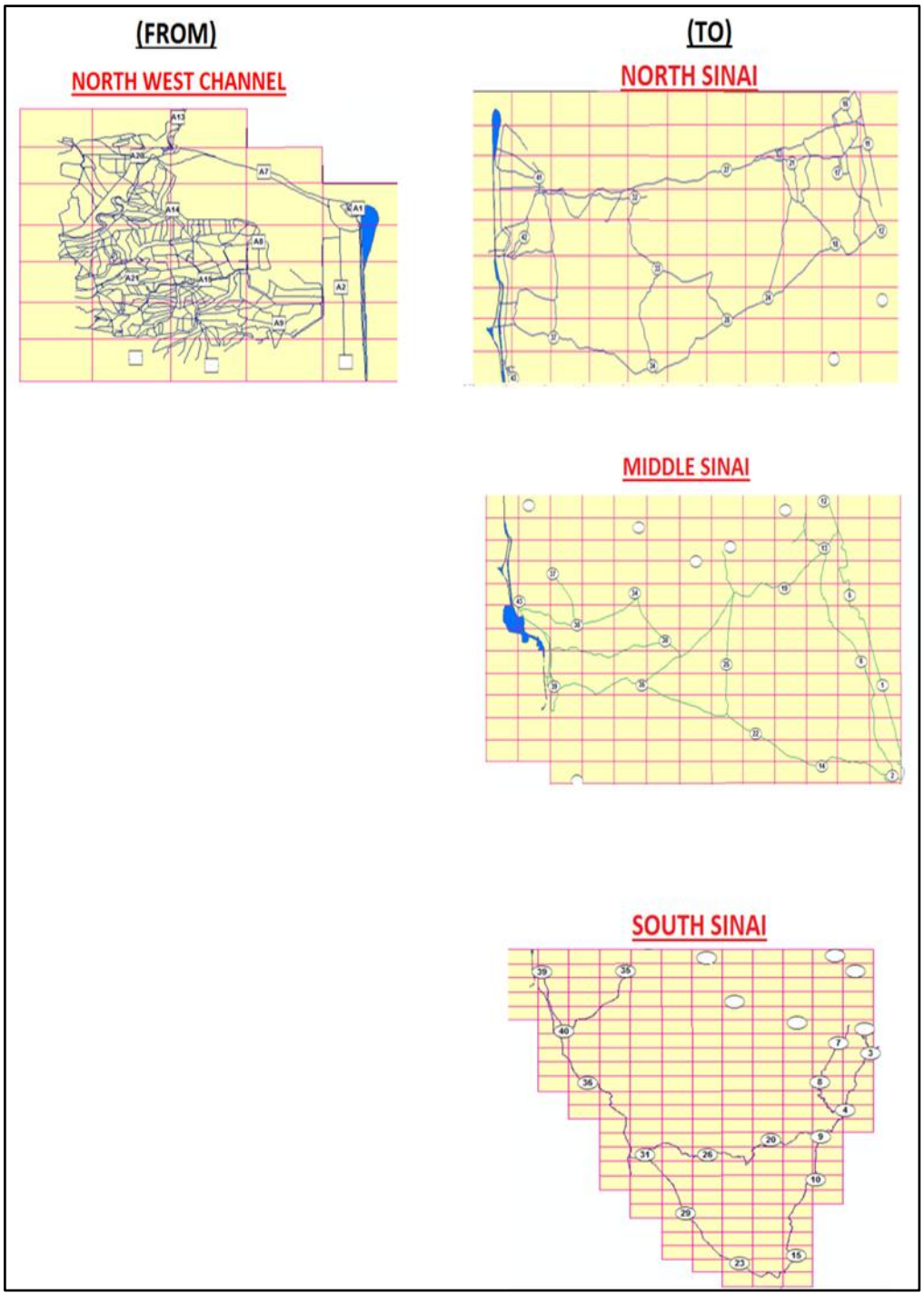


Figure 8: From North west to all Sinai ZonesScenario

Results, Analysis & Discussion

Table [1] presents a typical overall results for a specific trip origin [A1] in the North western zone on the west side of the canal. The table has three segments, each one for a different destination zone. The first segment shows the outcomes for the North Sinai region, the second segment for the middle Sinai region and the third segment for the south Sinai region. For any segments, the number of rows identifies the number of trip ends for that region. For example, for north Sinai, there is 16 rows representing the results for the 16 nodes representing the different trip ends within north Sinai. Each row, has five distances in the corresponding cells, starting with Before scenario, followed by After scenario with one tunnel active, then two tunnels active and so on till all allocated four tunnels are considered in the analysis. For each column represents a trip distance length, the following column represents the saving distance resulted from measuring the difference between Before/after runs. One can notice that this particular overall table for trip origin [A1], shows the results for a 215 runs by the network analyzer. Thus for the selected 15 trip origin, the total number of runs become 3225 runs.

In order to plot the results in a more convenient way, the normalized trip distance relationship is chosen to represent the results in an easy readable manner. Figure [9] represents a typical result from north west zone to north of Sinai with its four different plots, representing the four tunnels cases. To clarify, the X axis represents the trip distance in the Before scenario and the Y axis represents the corresponding trip length in the After scenario. The equal line is drawn on the plot to facilitate the tunnel effect on the trip distance. Of course, if the points lie on the equal line, it means no effect from construction of the tunnels. If the points lie in the upper triangle, it means negative impact of tunnel building. Finally, if the points lie in the lower triangle, it means positive impact of tunnel construction on the transportation activities. By carefully examining the four plots of figure [9], the first one shows a slight positive impact from activating the Ismailia tunnel. This was expected since the flow of the trips is focused from north zone on the left to north Sinai of the right, and the location of the activated tunnel is not suitable for these types of trips. However, the second plot shows a noticeable positive effect when the Port said tunnel is activated too. The deeper the points from the equal line, the more significant influence of tunnel existence on the trip distance saving. Adding, Ismailia 2 and Suez tunnels on the analysis didn’t contribute much to the positive impact as it was reflected by the port said tunnel.

Table 1: results of trips from zone (A1) in North West channel to (north, middle, south Sinai)

NORTH WEST CHANNEL									
FROM ZONE (A1)									
NORTH SINAI									
TO	BEFORE	ISMMAILIA TU		ISMAILIA TU+ PORT SAID TU		IS -TU+ P.S-TU+IS-TU (2)		IS -TU+ P.S-TU+IS -TU (2) +SUIZ-TU	
		AFTER one tunnel	SAVING DISTANCE	AFTER two tunnel	SAVING DISTANCE	AFTER three tunnel	SAVING DISTANCE	AFTER four tunnel	SAVING DISTANCE
11N	267.8	267.8	0.0	222.5	45.3	222.5	45.3	222.5	45.3
12N	290.4	290.4	0.0	245.1	45.3	245.1	45.3	245.1	45.3
16N	261.4	261.4	0.0	216.1	45.3	216.1	45.3	216.1	45.3
17N	258.8	258.8	0.0	213.5	45.3	213.5	45.3	213.5	45.3
18N	263.0	263.0	0.0	217.7	45.3	217.7	45.3	217.7	45.3
21N	226.7	226.7	0.0	181.4	45.3	181.4	45.3	181.4	45.3
24N	235.5	230.8	4.6	208.4	27.0	208.4	27.0	208.4	27.0
27N	190.8	190.8	0.0	145.5	45.3	145.5	45.3	145.5	45.3
28N	213.0	208.4	4.6	186.0	27.0	186.0	27.0	186.0	27.0
32N	146.3	146.3	0.0	101.0	45.3	101.0	45.3	101.0	45.3
33N	180.3	180.3	0.0	135.0	45.3	135.0	45.3	135.0	45.3
34N	166.9	162.2	4.6	159.5	7.4	159.5	7.4	159.5	7.4
37N	112.1	107.5	4.6	105.0	7.1	105.0	7.1	105.0	7.1
41N	97.8	97.8	0.0	44.4	53.5	44.4	53.5	44.4	53.5
42N	75.0	75.0	0.0	66.3	8.7	66.3	8.7	66.3	8.7
43N	104.9	102.4	2.5	101.5	3.4	101.5	3.4	101.5	3.4
MEDDIL SINAI									
TO	BEFORE	ISMMAILIA TU		ISMAILIA TU+ PORT SAID TU		IS -TU+ P.S-TU+IS-TU (2)		IS -TU+ P.S-TU+IS -TU (2) +SUIZ-TU	
		AFTER one tunnel	SAVING DISTANCE	AFTER two tunnel	SAVING DISTANCE	AFTER three tunnel	SAVING DISTANCE	AFTER four tunnel	SAVING DISTANCE
1M	411.2	411.2	0.0	365.9	45.3	365.9	45.3	365.9	45.3
2M	387.4	384.8	2.5	384.0	3.4	384.0	3.4	384.0	3.4
5M	354.9	354.9	0.0	309.7	45.3	309.7	45.3	309.7	45.3
6M	374.7	374.7	0.0	329.4	45.3	329.4	45.3	329.4	45.3
13M	304.8	304.8	0.0	259.5	45.3	259.5	45.3	259.5	45.3
14M	338.9	336.4	2.5	335.6	3.4	335.6	3.4	335.6	3.4
19M	289.2	284.6	4.6	262.2	27.0	262.2	27.0	262.2	27.0
22M	293.7	291.2	2.5	290.4	3.4	290.4	3.4	290.4	3.4
25M	290.6	286.0	4.6	263.6	27.0	263.6	27.0	263.6	27.0
30M	198.8	194.2	4.6	191.4	7.4	191.4	7.4	191.4	7.4
35M	217.4	214.9	2.5	214.1	3.4	214.1	3.4	214.1	3.4
38M	143.1	138.5	4.6	135.7	7.4	135.7	7.4	135.7	7.4
39M	156.7	154.2	2.5	153.3	3.4	153.3	3.4	153.3	3.4
SOUTH SINAI									
TO	BEFORE	ISMMAILIA TU		ISMAILIA TU+ PORT SAID TU		IS -TU+ P.S-TU+IS-TU (2)		IS -TU+ P.S-TU+IS -TU (2) +SUIZ-TU	
		AFTER one tunnel	SAVING DISTANCE	AFTER two tunnel	SAVING DISTANCE	AFTER three tunnel	SAVING DISTANCE	AFTER four tunnel	SAVING DISTANCE
3S	412.9	410.4	2.5	409.6	3.4	409.6	3.4	409.6	3.4
4S	469.0	466.5	2.5	465.6	3.4	465.6	3.4	465.6	3.4
7S	392.4	389.9	2.5	389.0	3.4	389.0	3.4	389.0	3.4
8S	427.9	425.4	2.5	424.6	3.4	424.6	3.4	424.6	3.4
9S	498.2	495.6	2.5	494.8	3.4	494.8	3.4	494.8	3.4
10S	535.4	532.9	2.5	532.1	3.4	532.1	3.4	532.1	3.4
15S	515.8	513.3	2.5	512.4	3.4	512.4	3.4	512.4	3.4
20S	471.4	468.9	2.5	468.1	3.4	468.1	3.4	468.1	3.4
23S	459.8	457.3	2.5	456.5	3.4	456.5	3.4	456.5	3.4
26S	406.5	404.0	2.5	403.1	3.4	403.1	3.4	403.1	3.4
29S	403.0	400.5	2.5	399.7	3.4	399.7	3.4	399.7	3.4

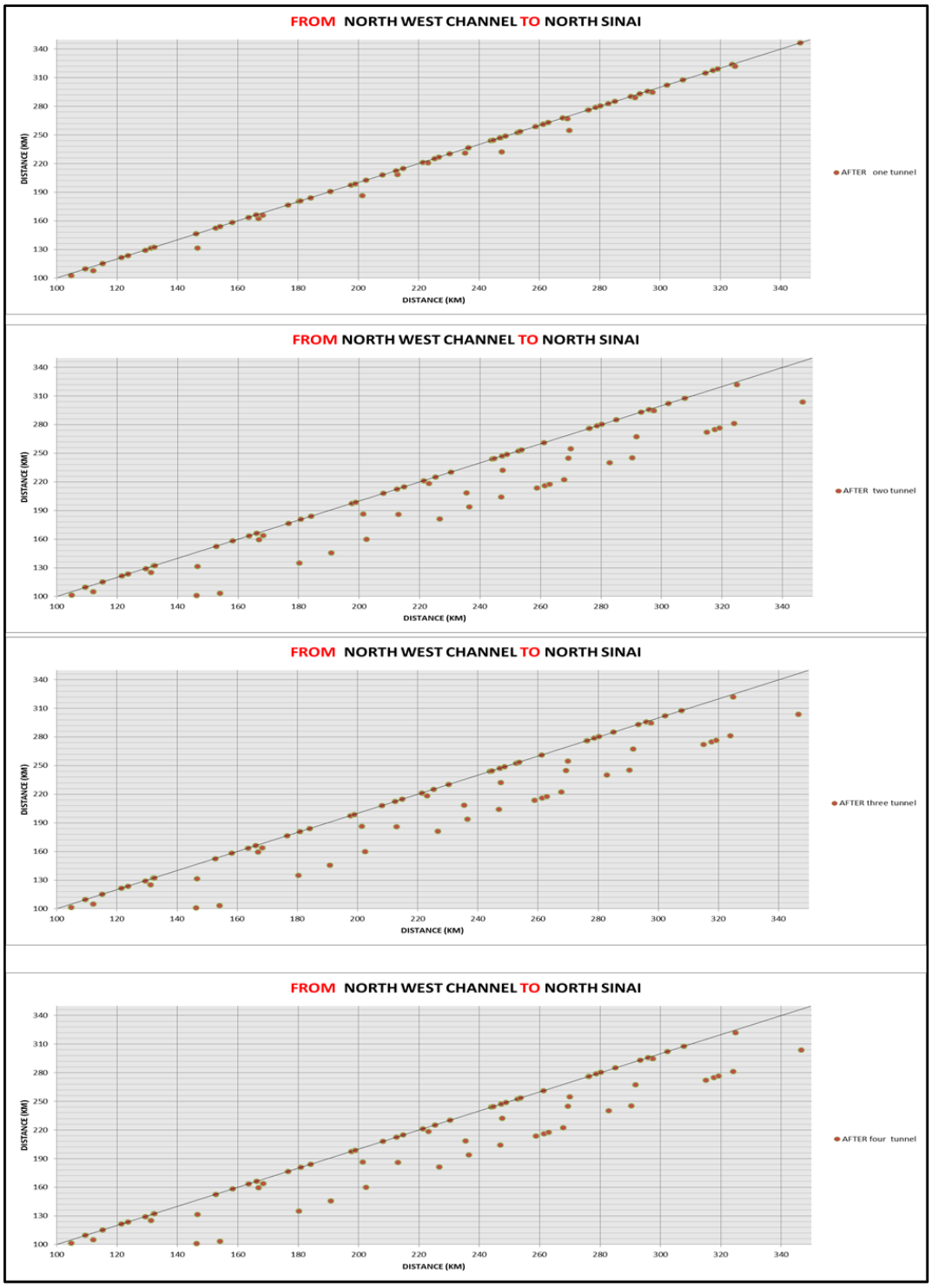


Figure 9: chart of saving distance after adding tunnels in trips from North West channel zones to north Sinai

Concluding Remarks

An attempt is presented through developed GIS approach to examine the effect of more passage stations [tunnels] along the sues canal to link the Nile Delta region with Sinai region. It was demonstrated that the sharing nodes through the tunnel(s) locations contributed in minimizing the isolation of the Sinai highway network. One can conclude that as the trip two ends lie closer to the area of the influence of the tunnel, the expected distance saving increases. Also, the percentage saving in the trip distances depends on the trip length itself. As the trip origin and destination are closer to the canal, the more benefits are gained from the tunnel construction. The highway saving distances due to tunnel existence can be projected in many ways. For example, the network maintenance regular programs will gain from such a saving. Also from the point of view of fuel consumption and the trip cost benefits. Finally, the positive impact from environment point of view and reduction in air pollution which makes the intended Sinai development takes a sustainable meaning.

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