GIS APPROACH TO INVESTIGATE THE IMPACT OF DEVELOPMENT CORRIDOR ON THE GENERAL TRAFFIC CIRCULATION IN EGYPT

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ABSTRACT: This study is based on the proposed development corridor project by Dr. Farouk El-Baz which attempt to expand the developed region westward throughout the Valley of River Nile. The aim of the current research is to investigate the impact of such a major super highway on the general movement of vehicle traffic in Egypt especially in the North – South direction. A Geographic Information System (GIS) Approach is selected for its suitability for such a problem at hand. Firstly, the selected alignment of the proposed developed corridor is digitized, and linked to the overall digitized national highway network of Egypt. The digitized process included the twelve branches highways throughout the River Nile Valley. The Scenario of With / Without Development Corridor is adopted to illustrate the impact of the project on different proposed expected journey linking Egypt between North regions [major harbors] and south regions [potential for development projects]. Also, the degree of development of the proposed super highway is considered in the study through varying design speed. The impact of the proposed project is presented in details on the Traveled Distance / Travelled time plot for different suggested Origin – Destination trips.

Keywords: GIS; Traffic; Development Corridor; DC; O-D.

INTRODUCTION

A development corridor was proposed by Dr. Farouk El-Baz in the west of the Nile River from the Mediterranean Sea Coastline to Egypt's southern board. The proposal would provide numerous opportunities for the development of new communities, agriculture, industry, trade and tourism around an approximately 2,000 km strip of the Western Desert. This particular strip of land was chosen because of its unique natural characteristics. It is basically flat with a northward slope from west of Aswan to the coast of the Mediterranean Sea. It passes close to vast tracts of fertile soils that are amenable to reclamation; most of such regions have potential for groundwater resources. The strip is also comparatively free of sandy areas; it is not crossed by lines of shifting dunes as in the case of regions farther to the west. Furthermore, the region is capable with plentiful sunlight and persistent northerly wind. These conditions allow the use of renewable solar and wind energy in the future. [1]

Figure [1] shows a landsat image of Development Corridor path on Egypt Map. Development Corridor Highway is composed of two classifications of highways:

1- North-South Highway 2- East-West Branches

The project includes twelve linkage highways throughout the River Nile Valley; Alexandria Branch, Tanta Branch, Cairo Branch, Faiyum Branch, Bahariya Branch, Minya Branch, Asyut Branch, Qena Branch, Luxor Branch, Kom Ombo-Aswan Branch, Tushka Branch and Abu Simbil-Lake Nasser Branch. [1]

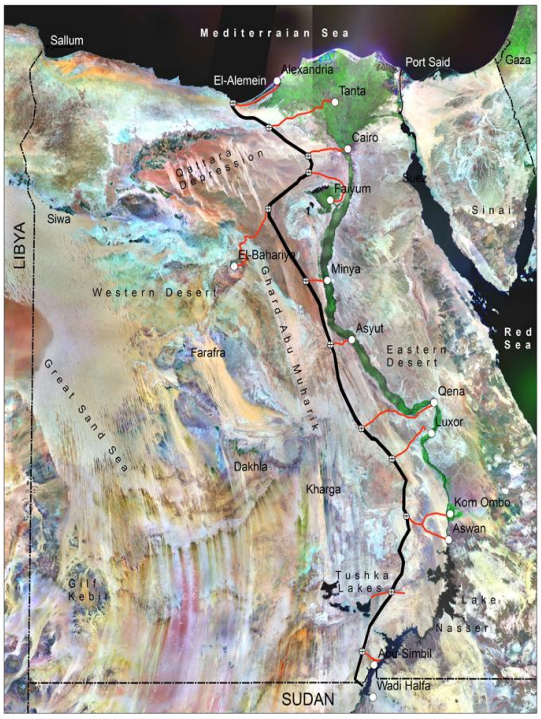

Figure 1. Landsat image shows Development Corridor path on Egypt Map [1]

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. [2], [3]

Applying the principles and applications of geographic information systems technologies to transportation problems is referred to as Geographic Information Systems for Transportation (GIS–T) [4]. 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?" [5], [6].

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 [7] through [15].

SCOPE OF THE PRESENT STUDY

The present research work seeks a suitable tool to enable us to investigate properly the existence of the suggested development corridor highway from a transportation point of view. In other words,

What is the effect of implementing the suggested major freeway to the national highway network?

In more details, the presents study attempt to address some of the following question marks.

Does the old Nile valley highways allocated along its path capable of handling the future growth of traffic volume associated with the expected economic growth?

What could be the expected time cost in terms of each ton-km travelled along the old North-South network in the coming years?

With the expected DC alignment, passing through all major potential spots for development growth, could a quantitative study be estimated, reflecting its importance 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 work, it has been chosen to formulate the present GIS system to tackle the current analysis problem. Figure [2] presents the general flowchart of the current GIS study.

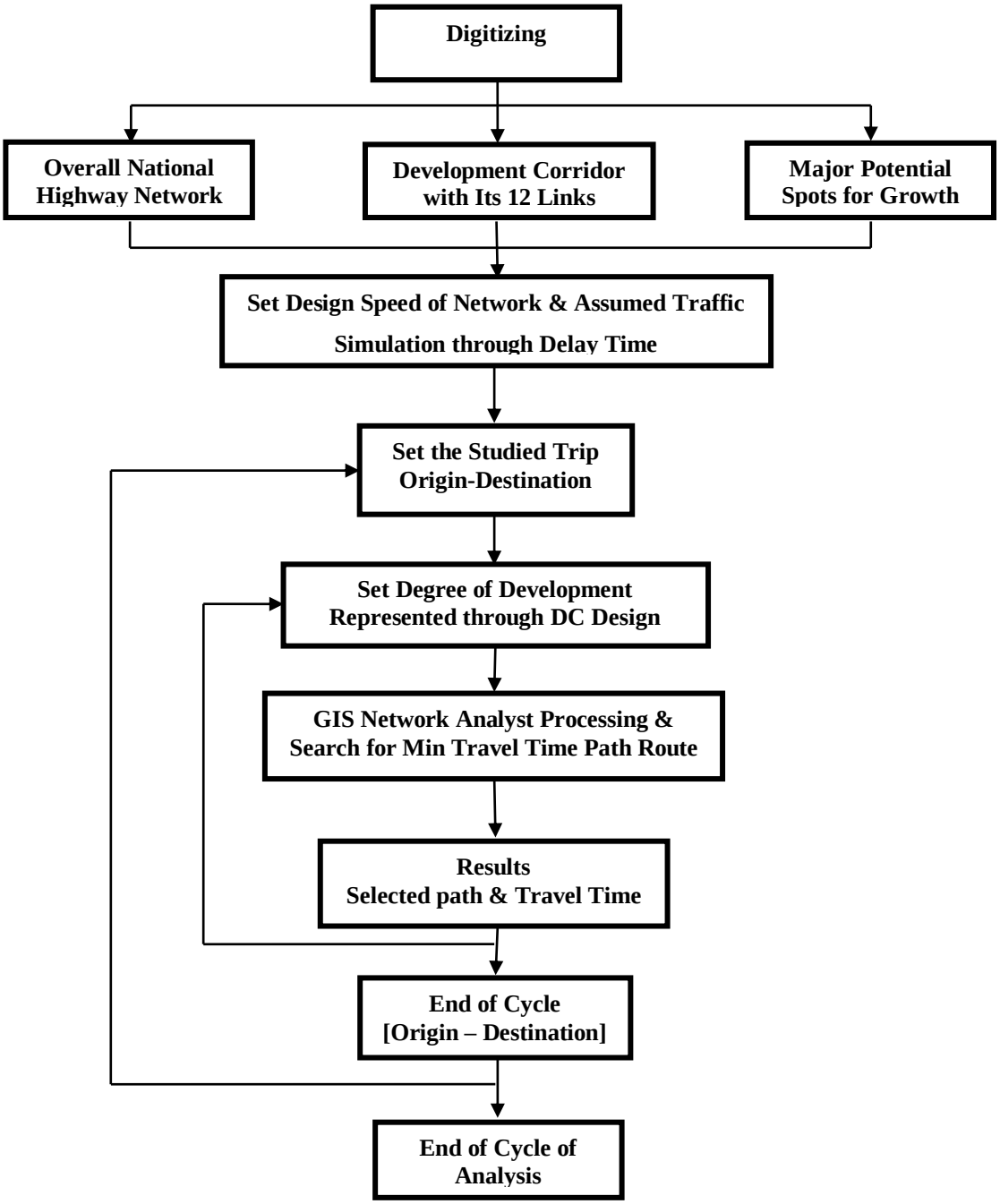

Figure 2. The general flowchart of the current GIS study

After the digitizing process and implementing the horizontal alignment of the DC project, a setting out of the general condition of the transportation network is conducted. Hence the nested loop of analysis is formulated with its outer range allocating the specific application of the studied major trip. It should be mentioned that North – South type of trips where mainly considered in the current stage of analysis. The inner loop of analysis was designed to reflect the degree of development of the DC freeway in terms of the suggested design speed. In the current study, three different speeds were considered ranging from 100 km/hr, 120 km/hr ending with 140 km/hr. After each inner loop of analysis, the relationship between trip travelled distance vs trip travel time can be evaluated and studied.

DATA COLLECTION, DIGITIZING & WORKING IN GIS ENVIRONMENT

Data representation is a main aspect of a GIS research, it refers to the ways in which geographic space and entities are structured in the analytical framework of a particular study.

This section shows data collection, digitizing process and working in the GIS platform. Firstly, the maps of main Roads of Egypt were obtained as scanned maps (Raster) [16]. Then they were inserted as group of layers (Vector) on GIS ArcMap classified by width of each Road as shown in Figure [3]. The database was constructed depending on width of each Road, number of lanes, number of Roads different posted speed and number of intersections [at grade & grade separation (interchange)]. They were recorded in Table [1].

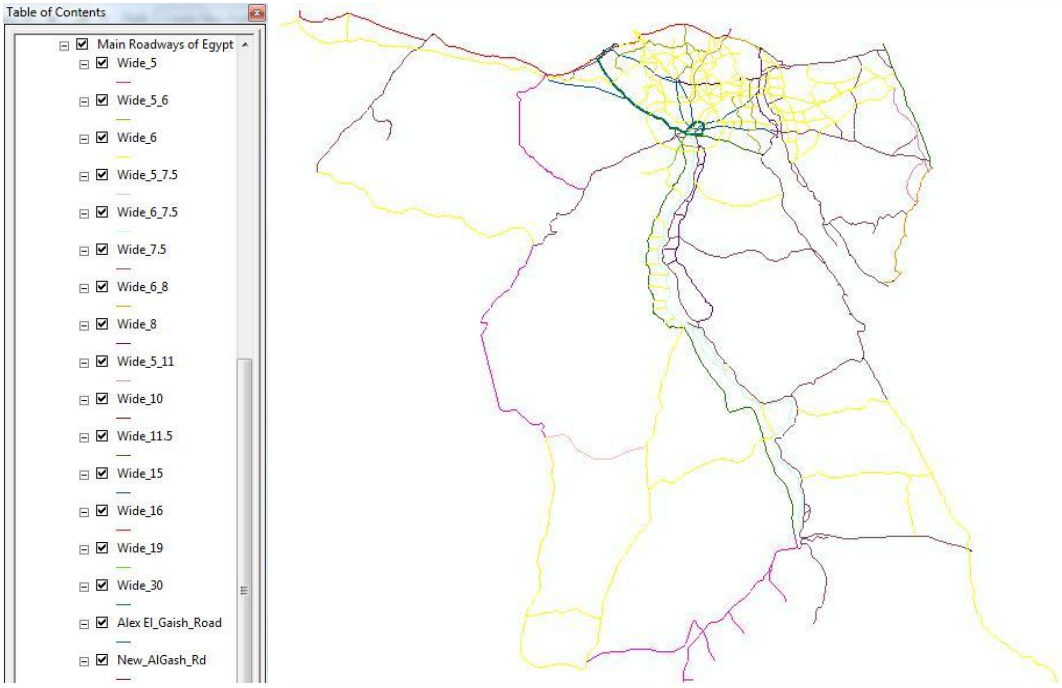

Figure 3. Digitizing of Main Roads of Egypt by using ArcMap

Note: the digitizing of main Roads depended on the maps of main Roads of Egypt from an official source.

Table 1. General information for Main Roadways of Egypt adopted in current study

Width of Road (m)	No of Lanes	No of Roads	Total Lengths (km)	Speed [17] (km/hr)	No of Intersections		
					At Grade	Interchange	Total
5	2	8	1489	90	14	1	15
5:6	2	4	524	90	26	5	31
6	2	71	8048	90	101	20	121
5:7	2	1	252	90	7		7
6:7.5	2	1	964	90	24	6	30
7.5	2	23	4986	90	119	11	130
6:8	2	3	490	90	22	4	26
8	2	1	182	90	17	1	18
5:7.5	2	1	194	90	2		2
10	4	10	222	100	26	5	31
11.5	4	4	1137	100&120	23	5	28
15	4	5	773	100	29	23	52
16	4	1	869	100	14	11	25
18	6	1	32	60	1	2	3
19	6	1	84	100	4	3	7
24	6	1	438	120	9	9	18
30	8	2	309	80&100	8	11	19
32	8	1	46	120		5	5
Total		139	21039		446	122	568
No. of Overlapped Intersections					114	50	164
Net No. of Intersections					332	72	404

The selected alignment of the proposed developed corridor is digitized by depending on the scanned maps (sectors) from the book of Dr. El-Baz as shown in Figure [4], and linked to the overall digitized national highway network of Egypt. The digitized process included the twelve linkage highways throughout the River Nile Valley.

Table [2] shows the statistics for development corridor (North-South Highway & East-West Branches).

As a result of linking the proposed development corridor with the current network of nation highways, the total number of intersections will increase. Table [3] determines number of intersections (at grade and interchange) as well as number of proposed intersections when implementation of Development Corridor, they will be grade separation intersections, this will be prefer for implementation this project as a super highway.

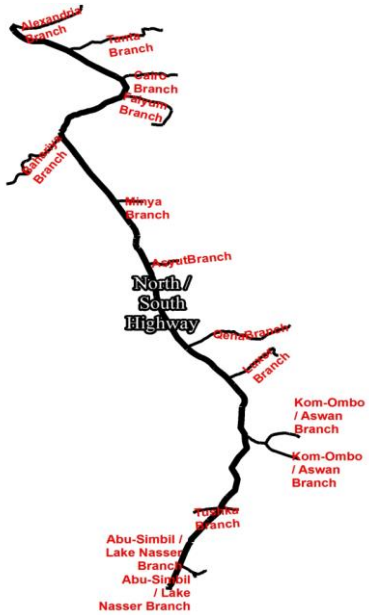

Figure 4. Digitizing of Proposed Development Corridor by using ArcMap

Table 2: Statistical table of Proposed Development Corridor

Classification		Total Lengths (km)	Speed (km/hr)	No of Intersections		
				At Grade	Interchange	Total
North-South Highway		1283	**Proposed 100:140**	—	23	23
East-West Branches	1. Alexandria Branch	118		—	66	66
	2. Tanta Branch	169				
	3. Cairo Branch	92				
	4. Faiyum Branch	128				
	5. Bahariya Branch	158				
	6. Minya Branch	45				
	7. Asyut Branch	56				
	8. Qena Branch	179				
	9. Luxor Branch	108				
	10. Kom Ombo-Aswan Branch	159				
	11. Tushka Branch	72				
	12. Abu Simbil-Lake Nasser B.	56				
	Total	2623		0	89	89
	No. of Overlapped Intersections			0	11	11
	Net No. of Intersections			0	78	78

Table 3. Overall general information for total number of network intersections

	Type of Intersection	No of Intersections	Total No. of Intersections
In Current Network	at Grade	332	404
	Interchange	72	
Proposed Development Corridor	at Grade	0	78
	Interchange	78	
	Total	**482**	**482**

Dr. Farouk El-Baz studied the most important industrial zones which are near his proposed development corridor; they are shown in Table [4]. As a result, he sees that Development Corridor will effect on the commercial movement between these industrial zones and different areas in Egypt such as different governorates, airports, and specially, ports. Using ships for trade is a better choice as a modal on the one hand transportation cost and transmitted shipment. [18]

Figure [5] shows the location of each industrial zone on an official map of Arab Republic of Egypt [Source: IDA (2010)]. As well as Figure [6] shows the digitizing of these industrial zones by using ArcMap. [18]

Table 4. Most important industrial zones around Proposed Development Corridor

Industrial Zone	Governorate	Coordinates		New or Old District
		Easting	Northing	
Burj Al-Arab	Alexandria	29.610299999980	30.862099999960	New District
Noubaria	Beheira	30.29789999970	30.41829999910	New District
El-Natrun	Beheira	30.35309999990	30.37069999990	Old District
6-October	Giza	30.96700000020	29.95370000040	New District
Kom Oshim	Faiyum	30.83870000020	29.46930000000	Old District
Dayrout	Asyut	30.83829999990	27.56090000090	Old District
Abnub	Asyut	31.14809999990	27.24489999940	Old District
Abu-Tij	Asyut	31.34059999980	27.04329999910	Old District
Sohag Al-Gadida	Sohag	31.72370000000	26.53669999910	New District
Al-Ahaywah	Sohag	31.80069999960	26.42930000090	Old District
Bani-Ghalb	Asyut	31.08870000020	27.17579999940	Old District
Nagaa Hammadi	Qena	32.29990000000	26.01180000040	Old District
Aswan	Aswan	32.87660000010	24.05580000020	Old District
Tahta	Sohag	31.51580000020	26.76889999960	Old District
Qota	Faiyum	30.46490000000	29.39750000090	Old District

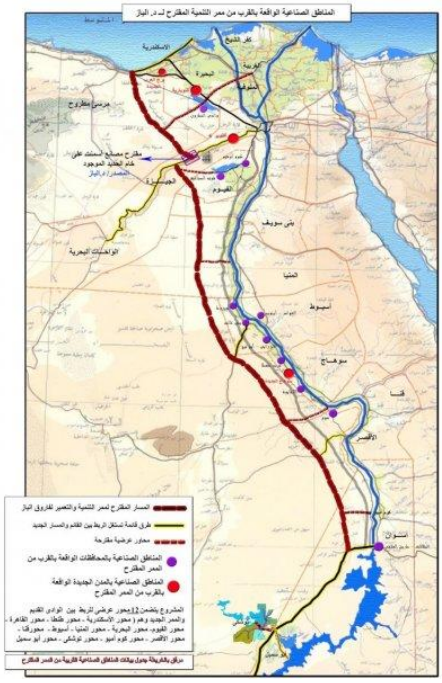

Figure 5. Location of 15 industrial zones close to Development Corridor on an official map of Egypt [18]

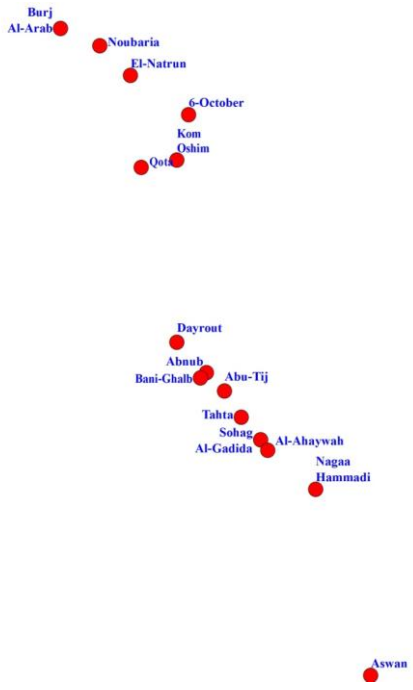

Figure 6. Digitizing of 15 industrial zones near Proposed Development Corridor by using ArcMap

Table [5] describes an example as a sample of attribute tables which represents the database that inserted for the nation highway network of Egypt. Also, Table [6] shows an example as a sample of directions of paths which were studied and extracted by using ArcMap.

Table 5. Sample of attribute tables

ID	Road Name	Segm. Length (km)	Segm. No.	Governorate	Direction	PSL (km/hr)	Avg. Travel Time (min)
3333	New Al-Gash Rd	28	1	Suez	2	120	14
3333	New Al-Gash Rd	32	2	Suez	2	120	16
3333	New Al-Gash Rd	16	3	Suez	2	120	8
3333	New Al-Gash Rd	17	4	Beni_Suef	2	120	9
3333	New Al-Gash Rd	26	5	Beni_Suef	2	120	13
3333	New Al-Gash Rd	35	6	Beni_Suef-Minya	2	120	18
3333	New Al-Gash Rd	17	7	Minya	2	120	9
3333	New Al-Gash Rd	21	8	Minya	2	120	11
3333	New Al-Gash Rd	112	9	Asyut - Minya	2	120	56
4444	New Al-Gash Rd Branch 1	12	1	Suez	2	120	6
4444	New Al-Gash Rd Branch 2	10	2	Suez	2	120	5
4444	New Al-Gash Rd Branch 3	5	3	Suez	2	120	2
4444	New Al-Gash Rd Branch 4	6	4	Beni_Suef - Suez	2	120	3
4444	New Al-Gash Rd Branch 5	8	5	Beni_Suef	2	120	4
4444	New Al-Gash Rd Branch 6	21	6	Beni_Suef	2	120	10
4444	New Al-Gash Rd Branch 7	25	7	Minya	2	120	13
4444	New Al-Gash Rd Branch 8	18	8	Minya	2	120	9
4444	New Al-Gash Rd Branch 9	27	9	Asyut	2	120	14

Table 6: Sample of directions from Nagaa Hammadi to Proposed El-Alemein Port

Description	% Used Length of DC through The Trip = 99.32%	Case (4): Development Corridor with Speed=140km/hr	Distance (km)	Time (hr:min)
Start at Nagaa Hammadi			0	0:00
Make sharp right on Nagaa Hammada / Al-Zrikat Link			6.3	0:14
Make sharp right on Qena Branch			128	1:06
Turn right on North / South Highway			556	4:09
Bear right at Bahariya Branch/Al-Bahareya / Giza Road to stay on North / South Highway			909	6:50
Finish at Proposed International El-Alemein Port			909	6:50

RESULTS, ANALYSIS & DISCUSSION

As shown in the flowchart of Figure [2], the main loop of analysis adopted in the current research work allocates the studied journey which might reflect the importance of the existence of the development corridor super highway. Two major trips were selected in the current stage of this ongoing study. One representing the South – North Traffic flow direction is represented by Nagaa Hammadi to proposed El-Alemein International Port. The other representing the North – South Traffic flow direction is represented by Alexandria port to Lake Nasser. The purpose of this choice lies on the importance of the four locations with the overall future economic development plan of

Egypt. Moreover, their relative coordinates with the proposed alignment of the development corridor major freeway. Also, as shown in Figure [2], the secondary loop of analysis allocates the degree of development of the proposed freeway represented by its suggested design speed. Therefore, the counter of the inner loop of analysis runs through four different suggested cases of analysis.

- Case (1): Without Development Corridor
- Case (2): Development Corridor with Speed=100km/hr
- Case (3): Development Corridor with Speed=120km/hr
- Case (4): Development Corridor with Speed=140km/hr

It should be mentioned that a parallel research study is undertaking focusing on how the traffic flow travelling through the national highway network can be best simulated in the GIS environment. A delay time concept is adopted which assumed along the network intersections in an attempt to reflect the actual travel behaviour. This delay time factor is viewed as an equivalent trip delay to the expected jam traffic density at major entrance / exit along various network intersections. In the current stage of the present work, the delay time factor is taken constant and equal to 10 minutes.

Figure [7] shows the relationship between Trip Distance in km and Trip Travel Time in hours for Nagaa Hammadi and Proposed El-Alemein International Port journey for the four studied cases as mentioned earlier. As shown in the figure the average slope of each path increases from case (1) to case (4) illustrating the positive impact of using the DC freeway where as the slope increases the overall trip travel time decreases. This data are summarized in Table [7] where in case (1) the overall trip time required 9:8 hour, case (2) required 8:35 hour, case (3) required 7:53 hour and finally in case (4) required 6:51 hour. The big save in travel time demonstrated the positive impact of using the DC proposed project. Also, the percentage of the used trip length projected on the DC path is shown in the same table. Again, as the GIS loop of inner analysis goes from case (1) to case (4), the importance of the DC freeway with the national highway network gets much clearer. This is shown in the % of the projected length on DC which increases from 0% in case (1) to 39% in case (2) to 75.91% in case (3) to 99.3% in case (4). In Figure [7], these percents are illustrated by the bold length of each path. Figures [8] through [11] present the actual minimum travel time path chosen by the network analyst of the GIS system. For example, studied case (1) is projected as a plan view with its selected path on Figure [8] and so on. The effect of implementing the DC freeway is best viewed on both figures for each studied case. For example, the studied case (3) which reflects a design speed of DC equals 120 km/hr can be carefully analyzed with its two figures in mind. To clarify, firstly in Figure [7] one can read that 75.92 % of the total trip length lies on the DC path showed on the plot by two bold segments. The first one is at the early stage of the trip length. Hence, a gap indicating usage of other parts of the national network, then and finally the second bold segment lies again or goes back to the DC path as the network analyst selected in his search for the minimum travel time route. One can complete the picture by referring to Figure [10] which presents the actual selected path on the plan view coincides exactly with Figure [7] but in different manner showing the actual selected parts of the national highway network.

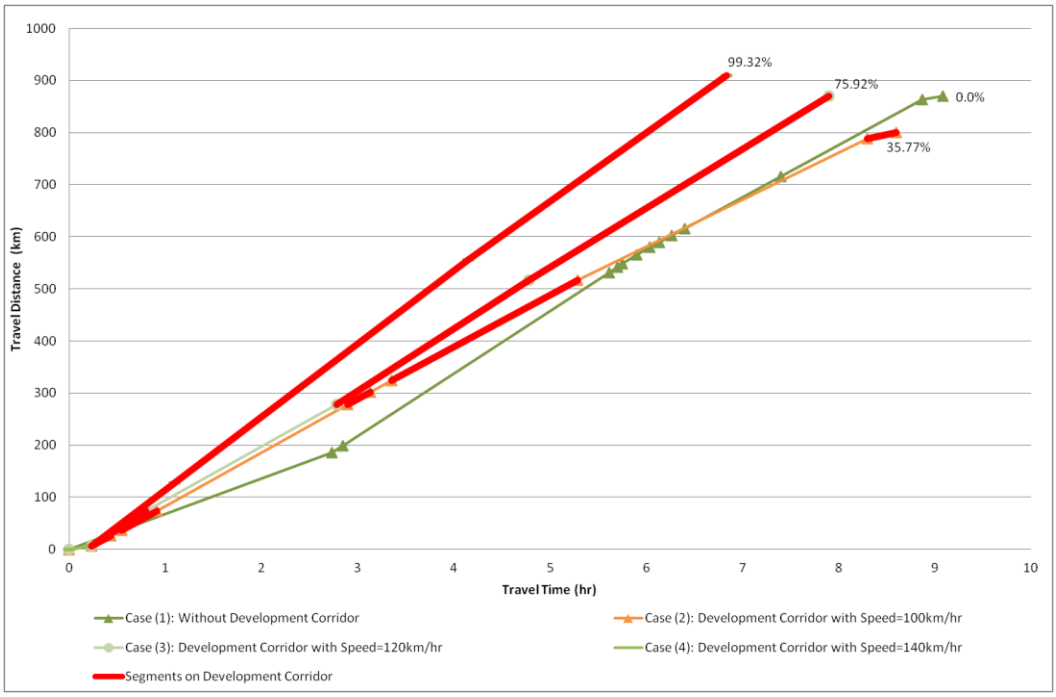

Figure 7. Distance / Time Diagram of Nagaa Hammadi - proposed El-Alemein Internationl Port trip for different studied cases

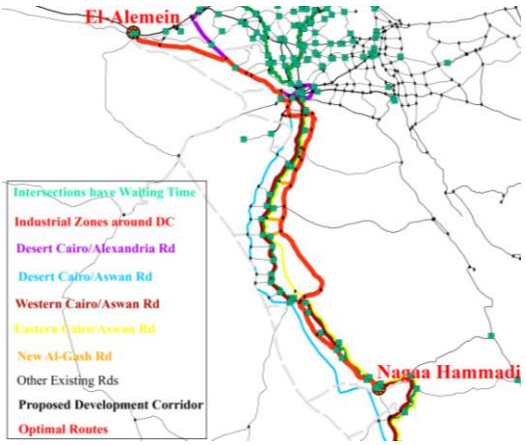

Figure 8. Trip from Nagaa Hammadi to Proposed El-Alemein International Port in studied case of without DC

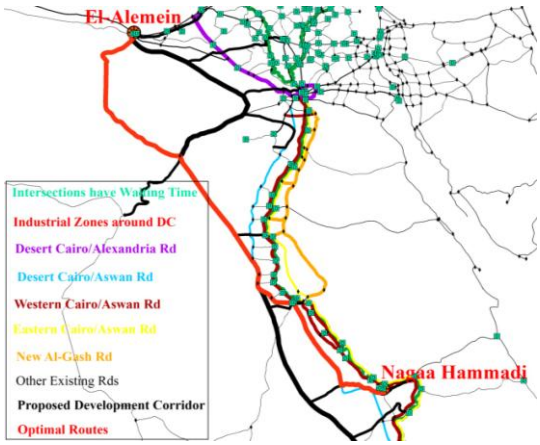

Figure 9. Trip from Nagaa Hammadi to Proposed El-Alemein International Port in studied case of DC with 100km/hr

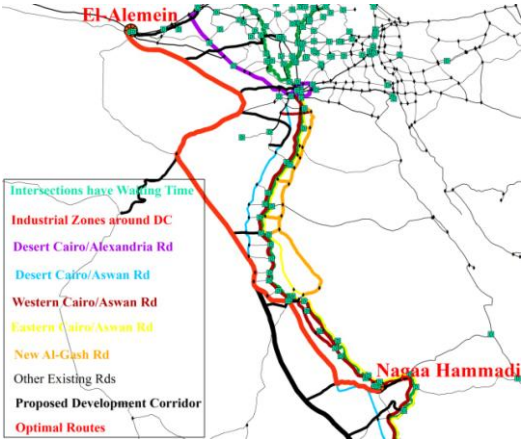

Figure 10. Trip from Nagaa Hammadi to Proposed El-Alemein International Port in studied case of DC with 120km/hr DC

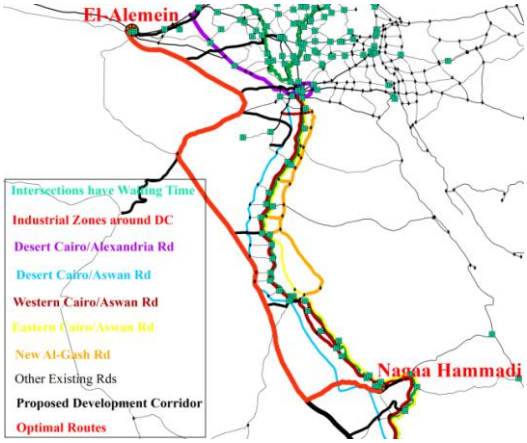

Figure 11. Trip from Nagaa Hammadi to Proposed El-Alemein International Port in studied case of DC with 140km/hr

The detailed output result for the other chosen trip directed towards the sudden region of Egypt, specifically starting from Alexandria port and ending up at Lake Nasser is shown in Figure [12] for the four studied cases. The accompanying illustration results as stated earlier are presented through Figures [13], [14] & [15].

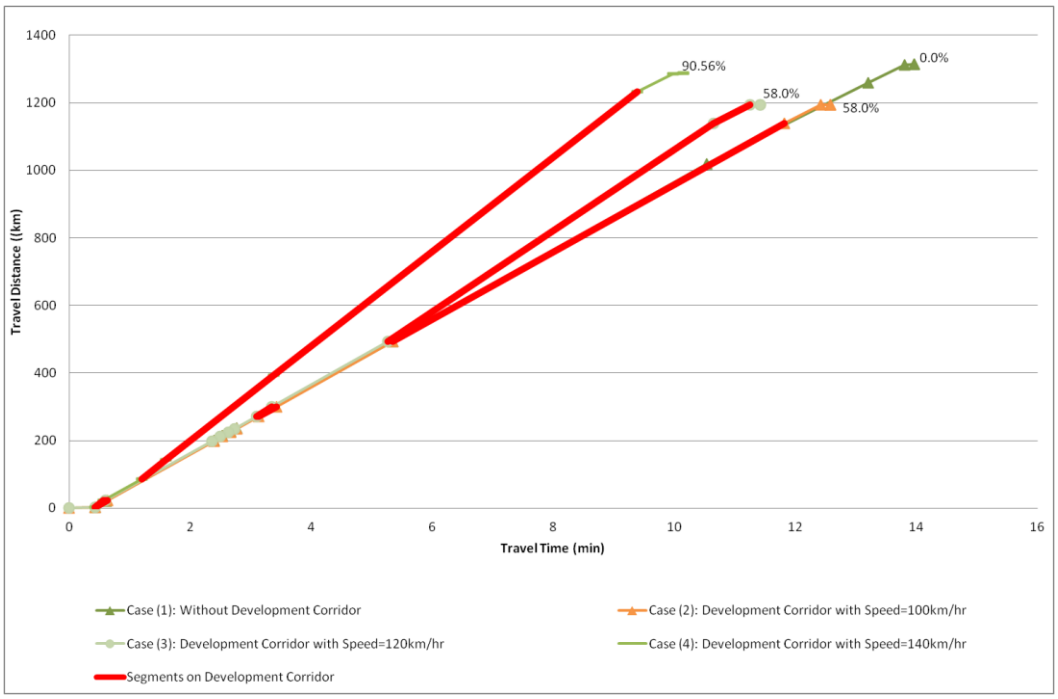

Figure 12. Distance / Time Diagram of Alexandria Port / Lake Nasser trip for different studied cases

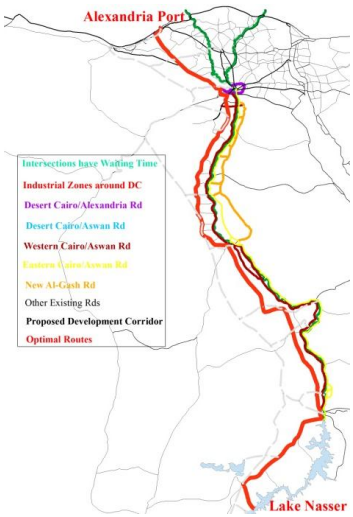

Figure 13. Trip from Alexandria Port to Lake Nasser in condition of without DC

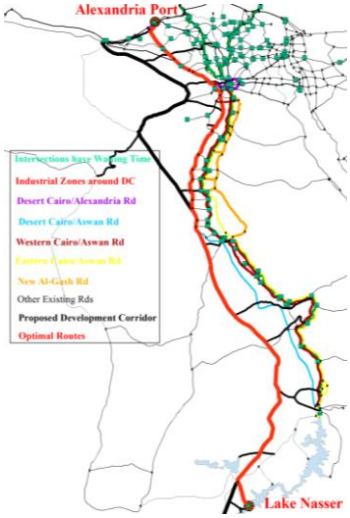

Figure 14. Trip from Alexandria Port to Lake Nasser in condition of 100 & 120km/hr DC speed

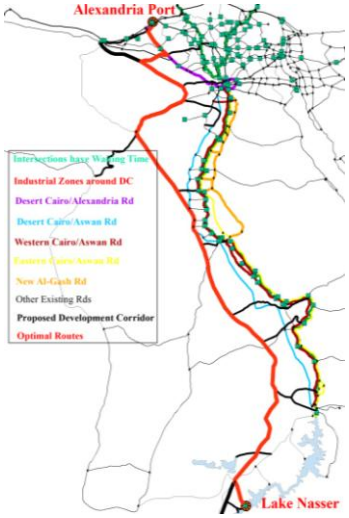

Figure 15. Trip from Alexandria Port to Lake Nasser in condition of 140km/hr DC speed

The following table (Table [7]) shows a summary for all that has been accomplished from the results of this study.

Table 7. A detailed output results for all studied cases

Trip Path	Case		Travel Distance (km)	Travel Time (hr:min)	Avg Speed through the trip (km/hr)	%DCL from Trip Length	%NSH	Δt (t_0-t_{DC}) min	Δd (d_0-d_{DC}) km
	Waiting Time (min)	DC Speed (km/hr)							
Nagaa Hammadi - Proposed El-Alemein Port	10	0	870	9:08	95	0.00	0	0	0
	10	100	801	8:35	93	39.00	20	33	69
	10	120	870	7:53	110	75.91	46	75	0
	10	140	909	6:51	133	99.30	61	137	-39
Alexandria Port - Lake Nasser	10	0	1313	13:59	94	0.00	0	0	0
	10	100	1194	12:35	95	56.00	49	84	119
	10	120	1194	11:26	104	58.19	50	153	119
	10	140	1287	10:10	127	90.56	85	229	26

CONCLUDING REMARKS & FUTURE WORK

The aim of the current research work was to study the influence of the proposed Development Corridor Freeway on the general transportation movement in Egypt, especially in the North – South direction. Therefore, A GIS approach was formulated for its suitability to such a problem.

The geometric alignment of the proposed project was digitized with its 12 branches and was linked to the national Roadway network of Egypt. A nested loop of analysis was conducted in the GIS environment with the proposed north – south journey representing its outer loop. The degree of development of the freeway represented by its suggested design speed allocated the end of the inner loop of analysis. The results showed the major positive impact of the project in terms of saved travel time and the portion of the projected length of the journey lied on the project longitudinal path. This illustrates the magnitude of the traffic volume that could be attracted from the old River Nile Valley Roadway network and directed to this super highway. Also, the results showed that regardless the direction of trip [North – South or South – North], the positive impact of the project still dominates. It is believed, that the outcome of the current on-going research study which focuses in details on the role of the delay time factor at major intersections and its effect on better simulation of the current traffic movement will add to the positivity impact of the development corridor highway project.

In terms of the suggested future work, it is recommended to extensively study the influence of the various industrial spots allocated along the path of the DC and try to link them with the national economic development plan to evaluate the rate of the expected growth. Hence the future traffic volume can be estimated to end up with a better understanding of the ranking needs of its different segments along its major 1200 km. Therefore, a valid recommendation of which segment(s) should be constructed first, and so on parallel with the national development plan. Also, the suggested delay time factor as a tool to reflect the actual simulation traffic flow along the national highway network should be addressed more carefully in order to have better reliable results. This includes the relationship between the adopted delay time in certain neighbourhood and its varying value during the 24 hr per day time together with its varying magnitude seasonal wise.

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