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Estimating the Effect of Newly Proposed Transportation Planning Development for Congested Urban Areas in Greater Cairo Case Study: El Fardous Axis, New Cairo

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KEYWORDS:
Traffic counts; Traffic Composition; Seed Matrix; Road network; Transport modeling; Trip distribution; Traffic assignment.

***Abstract*— This research aims at developing a transport model helping in conducting demand predicting for a newly proposed corridor, El Fardous axis, connecting East and downtown Cairo. The transport model is first calibrated and validated for existing traffic conditions and then, it is used to predict the future traffic conditions in the study area, as well as an assessment of the impact of planning data changes, including any proposed development. First, a study area was determined; then, a transport model was developed as a tool for the estimating the demand on the corridor at opening and future modeling years. The data available for developing the model are limited. The data consist primarily of traffic counts at selected locations during normal peak periods. Other data, such as socioe-conomic data and origin-destination studies, were not readily available. To overcome such challenges, an alternative approach was developed and applied in developing the transport model. This research proposes an advanced modeling methodology that tries to make best use of available data achieving the target accuracy. Also, it presents an evaluation of the impact of the proposed axis on traffic pattern and on level of service on the road network and the streets within the study area.**

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I. INTRODUCTION

EGYPT faces a significant demographic and urban expansion, where an entire population lives on only 7.7% of the land (Abd El Kader, 2011). Congestion, which affects both cars and buses, in the capital alone costs the national economy 2.3% of annual GDP [1].

More and new people are realizing that adding more roads does not alleviate the traffic congestion problem; in fact, it exacerbates it. Rather than expanding capacity to our highways, we should look for methods to improve the level of service provided by public transportation.

Congestion is a dynamical problem that is difficult to solve. It is made up of a variety of complicated processes and factors that interact with one another, such as cars, driver behavior, road geometry, traffic signs, and so on.

On a time range of years to decades, strategic transportation models forecast travel demand and network conditions.

With a population of 20 million people, Egypt's Greater Cairo Region (GCR) is the country's largest urban area and one of the world's most populous. Cairo, Giza, and Qaliubiya are the governorates that make up the Greater Cairo metropolitan area.

GCR is organized around its historic central urban area, which includes a central business district, outlying suburbs encircled by a ring road, and a belt of new satellite towns in the process of development, such as New Cairo, 15 of May City and 6 of October city. The region is home to the majority of the country's corporate offices as well as government agencies. As a result, the region attracts immigrants from both rural and metropolitan locations. As a result, the Greater Cairo Region's transportation demand is fast expanding.

As a result, Greater Cairo Region suffers from many traffic problems. These services are either formal or informal services; each include separate operators.

These operators are working separately with limited communication resulting in lack of connectivity, accessibility and reliability of the public transport system forcing residents to shift to private cars.

These problems may be resulting from deficiencies in the road network capacity and inappropriate driving behaviors. In addition, these problems are inflated by the steady increase in car ownership and population in recent years. The growing car ownership and transport demand result in widespread of traffic congestion on network reducing the city’s livability levels. Accordingly, the congestion negatively affects the productivity of inhabitants, as average trip length might take longer compared to free flow time.

For that purpose, the administration of the region tries to reduce the congestion by enhancing the road system capacity. The enhancement plan includes constructing new corridors such as El Fardous axis. This axis includes enhancing the functional classification of existing road and constructing new corridor.

This paper proposes an advanced modeling technique to transport modeling process undertaken for a newly proposed transportation Corridor (i.e., EL- Fardous axis to overcome the data shortage and process time constraint. The modeling process includes developing a seed matrix for daily traffic. The seed matrix is developed by adjusting CREATS daily person trips matrix. Then, OD estimation process is performed using the seed matrix and the traffic count data. Furthermore, trip generation and distribution models' area calibrated and validated based on the OD estimation results, existing traffic conditions and hence, it is used to predict the traffic conditions and demand on the proposed axis at future year.

Paper Objectives

- Reviewing of previous studies and researches related to the research point.
- Developing a transport model that Simulate the current situation in the study area
- Developing a target year model to undertake an evaluation of the impact of the proposed axis on traffic pattern, mobility and level of service inside the study area.

II. LITERATURE REVIEW

There have been many publications related to transport in Greater Cairo, Financial and Economic Feasibility Study for Cairo Metro Line which is provided the estimation of the volume of demand for transportation depends on the density and type of land use in the extension area and its relation to the region. Therefore, the socio-economic characteristics of the population in the extension area are identified in the Shubra Al-Khima section and the city center. The total population was about 1.4 million in 2001 and is expected to increase to 1.86 million in 2022, in addition to some statistics on the number of workers and students and the average monthly income of the families in both regions [2].

Also, according to (JICA 2002), In this study, they demonstrate that volume of transport demand is estimated by the proposed extension through the transport model developed where the model is used to identify changes in the transporting pattern of individuals as a result of changes in socio-economic characteristics, land use or transport network. In the case of the current study, the transport model was used to identify the number of passengers expected to be carried by the extension and the rest of the line in the opening year of the first phase (2008) and in the future [3]..

Also, according to (JICA 2006), they provide an efficient population which is estimated to be 22 million in 2022 which puts growing pressure on all infrastructure systems, including the road network system. GCMA requires unique and effective solutions to promote the functional integration of the region, and to provide a base for market-oriented transport activity[4]

Also, according to (JICA 2008), they provide an Existing population in the study area increased to 16 million in 2006, with an annual growth rate at 2.22% higher than that of three Cairo region governorates. The population growth was led by NUCs, which experienced a high rate of more than 10% per year in 1996-2006. [5].

The study area had an average density of 351 persons per hectare in 2006. Population increase is still progressing in the highly density areas, with an annual growth rate of 1.7%.

Two main studies were conducted. The first is CREATS, submitted in 2002. The second is the PPP Study, which was finished in 2006. The transport planning section of the current Strategic Urban Development Master Plan Study (SUDMP) prepared by the JICA Study Team is a follow-up study of both CREATS and PPP. The SUDMP started with verification of CREATS, replacement of the Expressway Network with the network proposed in the PPP. In the current SUDMP Study, field surveys undertaken by CREATS and the PPP are generally used without change. The structure of the CREATS transportation demand forecast models are used without modification in principle. The socio-economic structure has been newly projected by the JICA Study Team, based on the New Urban Plan that was studied and developed by the Team. Traffic demands are forecast based on the corresponding socio-economic structure predictions

They also give a good explanation of the "Public-Private Partnership "PPP" Program for Cairo Urban Toll Expressway Network Development" (JICA 2009). The research began in 2005 and ended in 2006. This study developed a funding plan for the commercialization and support of the PPP system structure, as well as a strategy for implementing PPP and implementing toll roads on the expressway network. In addition, a new body called the Metropolitan Expressway Authority (MEA) was envisioned to be in charge of all expressway-related responsibilities [6].

Moreover, (World Bank 2013), The study was conducted to assess the economic cost of current road traffic congestion in GCMA. It aims at preparing policy recommendations and an action plan to reduce traffic congestion. The study was of two phases. The first phase involves the review of traffic congestion in the GCMA, to identify their causes, types and, locations. Then, it assesses the overall economic costs and the associated energy inefficiencies. The study depicts a clearer image of CGMA’ complex traffic congestion problems and their associated costs. Finally, it provides the policy makers with a clearer image about the congestion problem real magnitude [7].

The second phase of the study involved prioritizing and recommending a package of specific monetary (e.g., congestion pricing schemes, fuel subsidies), regulatory (e.g., vehicle inspection norms and standards, regulation of public transport, public transport pricing), and investment (e.g., traffic management and public transportation investments) measures.

The first step was to conduct a thorough assessment of the data and information requirements. Several urban transportation-related studies and development master plans in Greater Cairo, including the comprehensive transport plans submitted by JICA from 2002 to 2008, were identified and analyzed as part of this research.

The morning peak period found within the period between 7:00 and 9:00 AM while the afternoon peak period has shifted from (13:00 – 16:00) to (15:00-18:00). The comparison of modal splits in 2010 and 2005 indicates that the share of passenger cars remains the highest and has generally increased since 2005. Also, the share of microbuses, minibuses and taxis has increased. On the other hand, the large bus share has dropped and so has the share of trucks. The latter could be a result of permitting trucks to use internal city roads only during night hours.

The method used to determine the causes, types, and locations of road congestion in the GCMA included a quantitative analysis that identified the causes and locations of congestion along the study corridors, as well as a network-wide qualitative analysis that focused on the causes of traffic congestion across the GCMA without regard to specific locations.

In compared to the morning peak, the evening peak has slower travel rates and more widespread crowded circumstances. The segmentation of the study region into four area types provides some insight into the observed congestion patterns. For the entire morning peak period, average speeds for all studied corridors inside the area defined by the Ring Road range from 20 to 45 km/h in both directions. For the evening peak, reduced travel speeds of 15 to 30 km/hr have been noted. The Ring Road has a somewhat higher average speed, ranging between 30 and 60 km/h depending on the peak period and direction.

The estimated Coefficients of Variation for all surveyed corridors, except for the 26th of July/15th of May travel corridor, fall in the range of 0.25 to 0.65. An increased variability in travel speeds is estimated for the evening peak compared to the morning peak for all surveyed corridors, with the exception of two locations. The highest variability in travel speeds is estimated for the 26th of July/15th of May travel corridor [8].

Among the numerous causes of travel time variability, traffic influencing events are major contributors. The most notable event type is vehicle breakdowns, which occur at a daily rate that is substantially higher than other traffic influencing events along all surveyed routes. It was also observed that higher frequencies of accidents, security checks and breakdowns occurred more on urban primary highways compared to the urban primary arterial routes. The analysis also reveals the substantial occurrence of both random microbuses stops and random pedestrian crossings on most surveyed routes.

The quantitative analysis also involved an assessment of the individual principal corridors, in which the aggregate as well as localized congestion causes were identified.

The analysis includes average speeds, coefficient of variation, frequencies of daily traffic influencing events, conclusions from space-time plots and a description of distinct congestion locations and causes along the route.

The causes of traffic congestion in the GCMA were classified into “operational” and “strategic”. Through the NGT, the panel of experts ranked the operational causes by degree of importance as follows: traffic management and control, design features of the road network, law observance and enforcement, awareness of road etiquette and manners, parking supply and behavior, traffic demand related factors, traffic influencing events and work zones.

The comparative assessment of qualitative and quantitative outcomes is summarized for each of the identified congestion cause categories, which include traffic management and control, design features of the road network, law observance and enforcement, awareness of road etiquette and manners, parking supply and behavior, traffic demand related factors, traffic influencing events, and work zones. For example, the “design features of the road network” was evaluated as one of the most salient causes of traffic congestion.

A simplified version of a congestion-sensitive strategic travel demand model predicts how many people, possibly stratified by socioeconomic groups, want to travel between zones of a study region on average by what mode (for example, car, public transportation, or other), given inter-zonal travel impedances such as costs and travel times. As a result, this simple model captures the decision to travel at all, as well as the choice of destination and mode, and its output is a set of origin/destination (OD) matrices, one for each demand segment and mode. [9].

Following that, travel demand models are classed according to how they explain the incidence of travel, how they reflect time and temporal relationships, and how they represent passenger heterogeneity. The talk focuses on individual person modelling. The assumptions about the mechanisms that lead to the occurrence of travel are the basis for the first classification of travel demand models. [9].

Traditional models of travel generation and spatial distribution are based on zonal attraction. This is the case in traditional gravity models, in which the number of trips between two zones is determined by the “size” (a function of area, population, facilities, and so on) of each zone and the “distance” between them (the actual distance or a function of inter-zonal travel impedance). This method is usually divided into two stages: Its initial phase forecasts trip production and attractions as a function of zonal variables such as the number of residences or work places in the area.. .. The second stage distributes trip producers to different zones based on the destination-attraction zone's and the generalized cost of travel to get from one zone to another. The majority of models based on zonal attraction are macroscopic and deterministic [9].

Activity-based travel demand models (ABDMs) are more contemporary models that are based on the behavioral assumption that people travel to complete activities in different places. Work at the workplace, go shopping at the mall, or chat at a café are some examples. As a result, these models forecast activities and their corresponding locations. Travel demand arises as a result of activities taking place outside of the individual's home. The majority of activity-based models are stochastic and microscopic [10].

The representation of time and temporal relationships in travel demand is a second classification of travel demand models. To begin, it's helpful to understand the differences between trip-based, tour-based, and all-day travel demand models. [10].

Trip-based models express travel demand as trips with an origin, a destination, a mode, and maybe other trip attributes. Travel demand is represented in tour-based models by trip sequences that begin and terminate at the same site. All-day models depict travel demand as a whole trip sequence over the course of a single day. [10].

While trip sequences may or may not be marked with starting times, tours and all-day travel itineraries, both of which comprise of trip sequences, are difficult to envision without a time dimension. The fact that most static travel demand models are based on trips and most dynamic travel demand models are based on tours or all-day travel plans reflects this. Static demand models anticipate the pace at which individuals travel from each origin to each destination by each examined mode during a stationary analysis time, often the morning or evening rush hour. While it is possible to model travel demand independently for each time slice, establishing a temporal interdependency between trips in various time slices is a bit more difficult. ABDMs, on the other hand, are often dynamic and based on a tour or all-day travel schedule. As a result, they forecast trip sequences with a temporal structure. The ability to link journeys also assures logical consistency between trips, such as when starting a second trip immediately after the first has been finished, or when going to the shopping mall by automobile also necessitates using the same mode on the way back.

When estimating travel demand, a third classification of travel demand models is based on its capacity to account for variability in the passenger population (in particular, their socio-demographics). This classification turns out to be significantly linked to the choice of a microscopic vs. a macroscopic modelling technique. [10].

Travelers differ in a variety of ways, including age, gender, income, car ownership, marital status, and ethnicity, and many of these characteristics may play a role in strategic planning aimed at cost-benefit analysis or equality assessments [11]. Due to the combinatorial difficulty of accurately expressing these dimensions, essentially two techniques have emerged.

Traditionally, a problem-specific stratification into a small number of population groups has been used. This necessarily results in some aggregate bias, and it also necessitates stratification before any analysis can be carried out. This approach is frequently used in conjunction with four-step (static and macroscopic) models, in which trip creation and attraction are computed independently for each population segment. However, activity-based demand models can be used per population strata [9,10,11].

Population synthesis is a relatively modern method. It draws synthetic individuals from a pool using a process that assures the final synthetic population is statistically consistent with the genuine one. Statistical consistency here refers to the replication of all summary statistics available from the real traveler population in the synthetic population; it does not imply that real and synthetic people are identical. Synthetic populations are best employed in combination with ABDMs, which are then used to anticipate each individual's activity, location, and trip sequences [12].

The great majority of traffic assignment packages, on the other hand, accept (time-dependent) OD matrices as inputs, equilibrate route choice in one way or another, and calculate (time-dependent) link flows, link travel times, and inter-zonal impedances (examples include Traffic Suite) (PTV)

As a result, the focus of this study is on route selection as the sole determinant of travel behavior. A route choice model and a network flow model are the two main components of a network assignment package.

In addition, the researcher examines route choice models, which require at least an origin, a destination, and a collection of route alternatives from which to choose. The choice of a route is governed by the routes' features, most notably cost in the form of (congestion-dependent) trip time [13].

Stochastic route choice models are more realistic than deterministic route choice models, but they are also more complicated to specify and calibrate. There are two issues that stick out.

The overlap of routes has a nontrivial impact on the design of the random component in the utility function. The design of both realistic and operational models for massive networks remains a difficulty [13, 14], despite the fact that the basic modelling principles are widely explored.

The distinction between static and dynamic route choice models is simple: dynamic models evaluate route costs (and thus utilities) at specific moments in time, whereas static models do not. Reactive travel times (derived from immediate network circumstances at the time of commencing a trip) and predictive travel times (taking into account that experienced network conditions depend on when a vehicle has arrived at a certain location in the network) are commonly distinguished [15].

Microscopic route choice models select a unique route for each vehicle (and hence can account for vehicle and/or driver variables in route selection). Macroscopic route choice models deterministically distribute vehicle flows across routes – deterministic macroscopic route choice models concentrate flows on low-cost routes, whereas stochastic macroscopic route choice models ensure that the share of vehicle flow on a route equals the probability of choosing that route [16].

For example, the researcher looked into all network flow models. Route flows are assumed to travel instantly through the network in static network flow models. The great majority of these are based on volume-delay functions, which use link flows to calculate link trip times. Although still extensively used, these models are insufficient to represent congested conditions: they anticipate flows beyond capacity, do not account for the spatial dispersion of queues, and implicitly presume that delay occurs within a bottleneck rather than upstream of it. Static network flow models are typically macroscopic and deterministic in practice [9].

There are several different types of dynamic network flow models. Simpler macroscopic flow models lack realism, whereas more complex models quickly become too complex to be used for network modelling (Lighthill and Witham, 1955; Richards, 1956); simpler macroscopic flow models lack realism, whereas more complex models quickly become too complex to be used for network modelling (Lighthill and Witham, 1955; Richards, 1956). Individual vehicles are moved through precise network geometries by microscopic instances that follow car-following, lane-changing, and gap-acceptance driving rules. “Mesoscopic” models exchange precision for speed, and frequently move groups of vehicles based on aggregate speed/density relationships while maintaining individual vehicle unit identifiability [17].

According to the fourth stage of the four-step approach, the researcher check combining a static route choice model with a static network flow model provides the standard static assignment package. The models in this category are usually macroscopic and deterministic. The solution procedure is usually interpreted in terms of a mathematical programmer aimed at satisfying some equilibrium condition [18].

When a dynamic route choice model is combined with a dynamic network flow model, the result is known as "dynamic traffic assignment" (DTA). Macroscopic route choice and macroscopic network flows are common configurations, as are microscopic route choice and meso- or microscopic network flows. The fully macroscopic approach is typically approached from the mathematical programming perspective, whereas the meso-/microscopic approach is frequently approached from the heuristic standpoint of directly mimicking demand/supply relations (although efforts exist to also introduce mathematical rigour into this process) [17,19,20]

The four-step approach [9] is the typical technique of structuring strategic transport models. The total number of daily travels in the future year of interest is estimated in the first stage, which is called trip generation (or trip frequency). A trip distribution model distributes these trips between origin and destination zones. The generated O-D matrix is then further partitioned amongst transport modes using a mode split model in the third phase. Finally, the mode-specific OD matrices, which indicate travel demand, are sent into the network assignment programme, which simulates vehicle assignments to road segments (network links). A route decision model including travel is included in the assignment package

Route choice is an aspect of travel behavior, such that its inclusion in a travel demand model appears more plausible from the behavioral modelling perspective. Despite of its advantages, this approach is not yet widespread but present in what is called the agent-based modelling approach [20]. Travel behavior that is more detailed than the route choice (car following, lane changing, and the like) is typically not included in the travel demand model but represented in the network flow model, both in traditional and agent-based models. The justification of this simplification is that given that a traveler is able to follow a route, it does from a strategic planning perspective not matter what detailed driving actions were necessary to perform that trip.

The interactions between a traditional travel demand model and a network assignment package is most frequently in terms of OD matrices (output of the demand model, input to the network assignment) and travel time matrices (output of the network assignment, input to the travel demand model). More disaggregate data structures are possible in the traditional approach, and they are characteristic for the agent-based approach. In any case, the solution of the models' systems is found by bringing the demand and supply side in an equilibrium or a relaxing state. This is usually achieved by iterating between the different components of the model system. The integration of all model components is essential for strategic transport models, which require the demand side to be endogenous and sensitive to conditions and changes of the network.

The objective of the following presentation is to elaborate on if and how different types of travel demand models and network assignment packages can be integrated into one strategic transport model system. This depends on the properties of each component, the relevant dimensions of which have been laid out before. Strongly related to these model properties are the properties of the data moved back and forth between the model components. The size and complexity of the resulting model system also raises computational concerns, which may enforce otherwise undesirable simplifications.

III. RESEARCH METHODOLOGY

This chapter introduces the methodology followed by the Researcher for conducting the Research. The methodology is related to conducting transport planning for a certain study area in order to achieve predefined goals. These goals may be related forecasting travel demand within the area, etc.

These methodologies mainly depend on performing OD estimation process. This process uses a seed matrix (e.g., historical matrices), recent traffic count survey, roadside interview survey, and any O-D related surveys. For most application, only traffic counts and seed matrix are used to perform the O-D estimation process.

This process accuracy depends on the accuracy of the seed matrix in expressing the demand pattern in the study area. The resulting O-D matrices for various vehicle types and occupancy levels are used in a traffic assignment algorithm and several key network performance indicators are estimated.

Example key performance indicators on the network level can include measures such as average travel time, average travel distance, etc. These indicators are calculated to assess the proposed change in the transportation infrastructure in the study area (e.g., construction of new axis road, adding of new transit service).

Figure 1 shows the study area of the highway axis, and the study area was monitored using Google Maps inside the area of Greater Cairo.

This paper applies a methodology that depends on O-D estimation process as shown in Figure 1. The methodology starts with Traffic volume demand estimates of expected demand for the Axis and No- Axis scenarios for different modeling years (i.e., 2019-2024) is shown in methodology is divided tasks as shown in Figure 2.

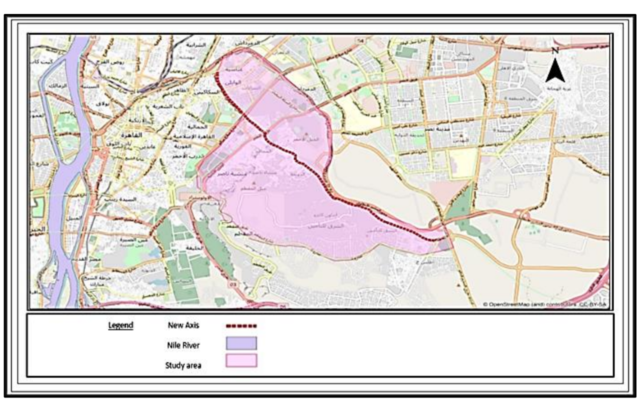

Fig. 1 The Location Of The Study Area Within The Governorate of Cairo

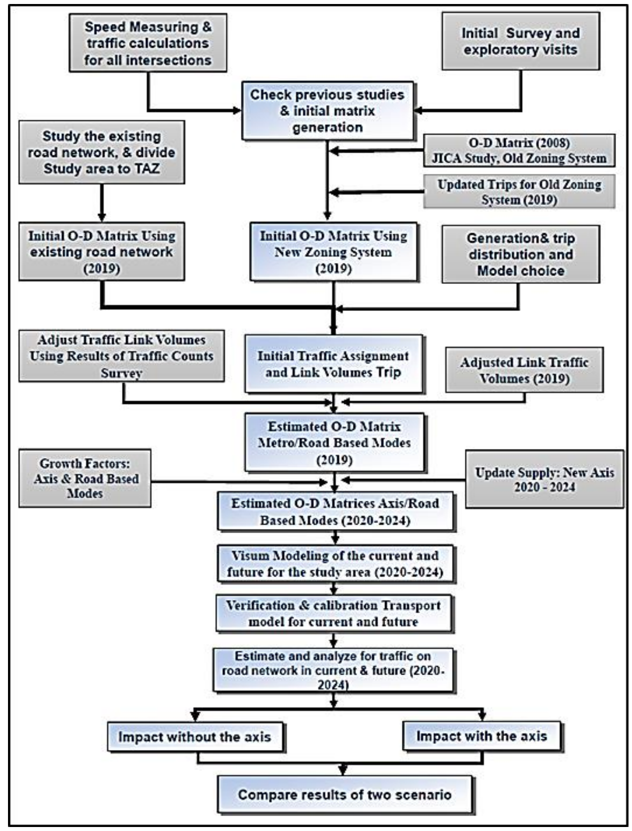

Fig. 2. Research Methodology General Framework

Several network level performance indicators will be estimated from the model and these include:

1. Total travel time
2. Average travel time for each mode
3. Total travel distance
4. Average travel distance for each mode.
5. Total Travel for AM, PM peck hours
6. Level of Service on Network links.

Three main scenarios that are considered in this study are:

- **The corridor Scenario**

The Researcher extracted the measure of performance for the axis scenario that will be used in the benefits calculations. This scenario was applied to modeling years (2019-2024).

- **The No- corridor Scenario**

The Researcher eliminated the metro lines and run the model to estimate the no metro scenario. This scenario was applied to modeling years (2019-2024).

IV. DATA COLLECTION

The first step in the model development process was the collection and analysis of relevant data. As the available data was known to be quite limited, it was expected that a standard planning model methodology would not be possible to follow. Therefore, the type of data available guided the development of the methodology for the development of the model. Available data was classified into two categories: network data and demand data.

1) Supply Data

Data in this domain consists of the information that allows the definition of all the attributes of the network, such as roadway widths, number of lanes, curves, slopes, grades, and intersections.

The axis of the highway of Cairo Governorate is located in the northeastern part of Greater Cairo Governorate, and the land on which the project is located is a crowded populated area with big service and commercial areas, and many important traffic network hubs pass through it.

This is site of the axis to be established is located at a distance close to each From the axis of the highway, as well as it is near the vital areas of Cairo Governorate (Down Town) and Mokattam area.

The location of the Autostrad corridor on the east surrounds the ring road and on the west side, the 6th of October Bridge, and it is bordered on the south by the Autostrad road with the ring road.

The study area was classified into minor, major, secondary and local roads.

- **Arterials Road and Bridges**

The main roads are the roads that link the axis to each other as a major network as a whole, and they link the collector's roads together.

On other hand the function of the main roads surrounding the axis is to collect a large traffic volume from traffic (from / to) the axis and at relatively high speeds in order to achieve the link between both the Nasr road and Salah Salem Road, the Ring Road, Marshal Tantawi, and the axis of the martyr road.

This is to transport people and goods from / to the axis, out of it also to regional and express roads, and vice versa. There are also many important bridges that are major roads in the study area, including October 6 Bridge, Ahmed Said, Abbasia Bridge, Firdous Bridge, and Ghamrah Bridge.

- **Major and Minor Collectors**

The main objective of collector roads to link traffic between the main roads and secondary roads, whereby the main roads collect vehicles out from different regions around the axis to be constructed and connected to the main roads to the various major neighboring regions and then to regional and express roads.

The function of urban collector roads is also similar to that of the main collector roads, but it connects the local roads and streets of the city to the main roads on its way to the main roads.

- **Local Streets**

These are the service roads for residential areas adjacent to the study area and are designed to serve the housing units

The Majority of local road located in each residential area around the study area, and consideration is given to the creation of parking spaces on both sides of the local roads outside the road boundary so that future traffic congestion does not occur.

2) Demand Data

For defining the demand parameters of the model, the important considerations are existing and future land uses as well as traffic conditions.

In cooperation with the architectural planning engineers, the administrative division of the study area, the urban space, the uses of lands and the mixed-use areas in the study area, and the preparation of the working facilities and workers in the study area were clarified.

Figure 4 shows Sheikhs in the study area in study area , And Figure 5 shows the geographical divisions within the study area. Then, Figure 6 shows traffic location point and speed point in the study area

- **Administrative division of the study area and urban space**

The study area is located within the area of the Cairo Governorate in the four departments, namely Al-Waili, Nasr City, Al-Darb Al-Ahmar, Minshaat Nasser and Al-Khalifa. According to the General Mobilization and Statistics Authority, there is in the study area as a total population of all their age divisions to 4414480 people, where the area of the area is 26455310 square meters.

- **The uses of lands and mixed-use areas in the study area**

The development of residential areas was monitored through the geographical maps of Google over an 8-year period, and it was found that the annual population increase of the study area does not exceed 2% of the total population.

- **Operating facilities and workers in the study area**

The study area contains 40791 establishments operating in most of the different disciplines. Table 1 shows the preparation of the working establishments for each department in the study area.

Table 1: Preparing operating establishments for each department in the study area.

- **Site inspection and Pilot Survey**

The primary source for traffic data was a series of traffic counts undertaken for this

Study

Counts were undertaken at locations throughout the study area, including an outer cordon (12 locations) to capture the major entry and exit points for the study area,

The intersections in the study area were visited, and the initial traffic count of the study area was made, as it was visited at the morning peak time of the axis of the Mousher corridor (NA), the axis of the Shaheed corridor and the extension of Ramses and October Bridge in the evening period. The study area was explored and its features were determined on 24/09/2019.

The Researcher visited 9th Street, Al-Nafoora Square and Salah Salem on 09/25/2019. The Researcher assigned the field survey team the initial traffic survey for the morning and evening periods for a number of alternative axes for the axis to be established after the intersections in the study area were identified.

The Researcher restricted traffic in some intersections for only 60 minutes in the experimental inspection, to know the traffic volumes in the estimate and the road classification of the roads

Alongside, the number of lanes and the types of vehicles, and through the visit the team designed the forms for a full field survey of all the roads that the student has determined. The results of the initial count for every 60 minutes of the two periods are shown in Table 1.

The study area also contains housing units with a number of 647,559 housing units for the whole region. Table 2 shows the total number of units for each department in the study area.

TABLE 1
PREPARING OPERATING ESTABLISHMENTS FOR EACH DEPARTMENT IN THE STUDY AREA

Section	No. Operating facilities
Waili	4777
Monshaat Nasser	13943
Khaliph	6160
Red Darb	12513
Nasr City	3398

TABLE 2
THE NUMBER OF UNITS FOR EACH DEPARTMENT IN THE STUDY AREA

Section	Number of Units
Waili	30090
Monshaat Nasser	84702
Khaliph	39634
Red Darb	32120
Nasr City	373101

TABLE 3
TRAFFIC VOLUMES ARE MEASURED FOR 60 MINUTES FOR SOME AXES

Section	Traffic Out Veh/(Hourly)	Traffic In Veh/(Hourly)	Traffic Out Veh/(Hourly)	Traffic In Veh/(Hourly)
	Am	PM	Am	PM
Mousheer	7986	7789	7186	7596
Salah Salem	14365	13969	14233	13983
6 of October	3985	3789	3120	3896
Ramses	4062	4110	4492	4636
Autostarad	5236	5211	5599	5696

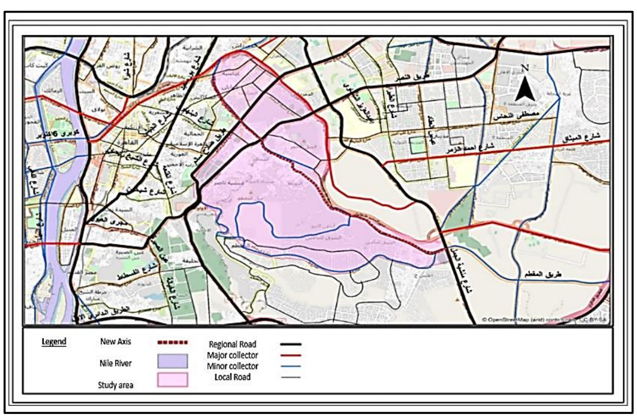

Fig. 3. The Road Classification Of The Road Network Within The Study

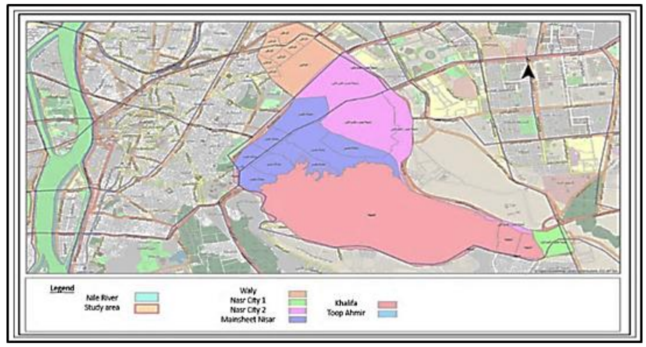

Fig. 4. Sheikhs In The Study Area

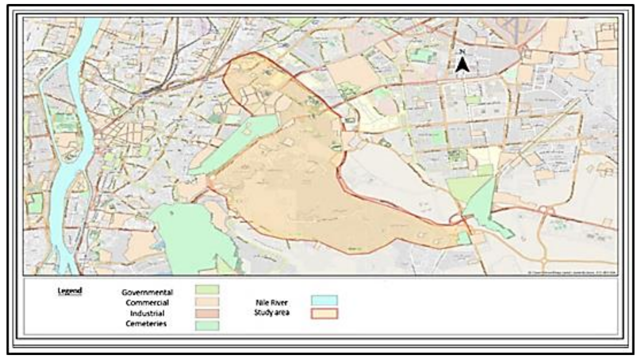

Fig. 5. The Geographical Divisions Within The Study Area

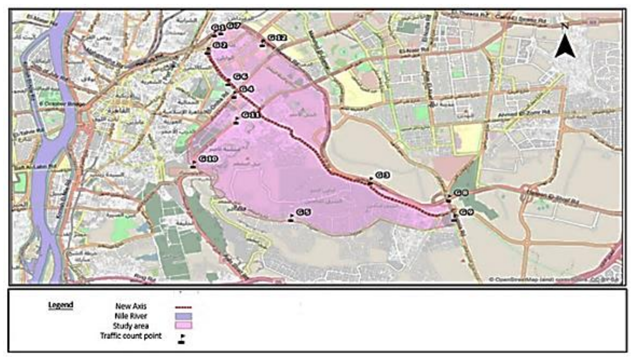

Fig. 6. Traffic Location Point And Speed Point In Study Area

V. THE MODELING APPROACH

A. Establish Zones

The next step in developing the geographic files was to define the zones in the network. Typically, the zones are defined based on the characteristics of the area, such as residential areas (mixed use), commercial areas, and hotels. The information gathered from aerial photographs was used to establish the best zonal configuration, supplemented by characteristics such as land use and the socio-economic profile of the areas obtained from other sources.

B. Network Structure

The network model was developed based on existing data and information assembled for the study. This includes data about the roadway network, traffic and passenger demand on the network, planned projects, and future developments in the region. The geographic files (network files) of the models were developed based on the satellite images and digital restitutions. The following subsections describe the steps involved in developing the geographic files.

C. Road Network

The modeled highway network includes all streets, roads, and highways that make up the regional roadway system. The basic elements of the network are nodes and links.

The first step in developing the network was to define the node positions. The node positions were indicated in geographic coordinates to allow flexibility for other future applications.

The next step for developing the network was to define network links. Among the link attributes, the link type, capacity, and free flow speeds had to be established for every link in the network. The road network was classified into six different categories of links: Freeways, Highways, Arterials, Major Urban Streets, Secondary Urban Streets, and Minor Urban Streets.

Geometric definition of the network and its components (roads, intersections, and ramps) were taken from the satellite images and the digital CAD restitution. Capacity of each link was calculated based on the collected information. The capacity of each roadway was calculated based on the HCM 2000. The available data did not contain the estimates of the free flow speeds on the network links. Therefore, the free flow speeds for each road class were assigned based on the HCM guidelines.

D. Volume-Delay Function (VDF)

Volume-Delay function (VDF) has been used to describe the relation between traffic volumes and delay experienced by travelers on the roads traveling from origin to destination, which has been adopted in traffic assignment. For the purpose of more precise description of traffic pattern, the researcher has to estimate the parameters of VDF in for each link type as shown in figure 8

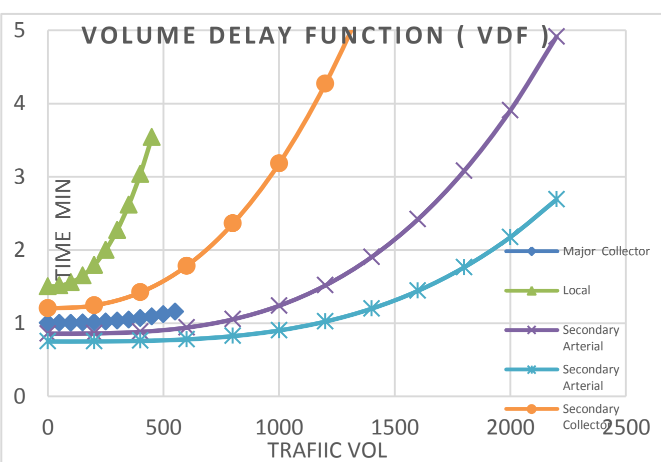

Fig. 7. VDF In For Each Link Type In The Study Area

E. OD Matrix Estimation

The main challenge in this study is related to the need to provide reasonably acceptable indicators of what would be the impact on Greater Cairo travelers if the Metro was not built. If time and budget would allow, this could be done using a full-fledge transport study including an extensive O-D survey. Since this is not the case; the student has adopted a procedure through which future O-D matrices are developed using historical O-D matrices and recent traffic counts. Figure 8 shows the Conceptual Framework for estimating future O-D matrices for Greater Cairo using historical matrices and recent traffic counts.

F. Current Demand

After developing the network, the next step was defining the demand for different scenarios. The challenge of this work was to develop the best O-D matrices based on the available data. To obtain an appropriate O-D matrix, a good starting seed matrix is required, along with the counts at a reasonable number of locations. In this case there was no seed O-D and the counts were limited. Missing data was impossible to obtain within the given timeframe, because the most exigent scenarios represent annual events for which surveys are unavailable.

Figure 3 shows the method that was adopted to estimate the O-D matrices for different scenarios. This follows one of the standard O-D estimation procedures, with some supplementary modifications and checks to make up for the lack of data. These steps were implemented in Visum to obtain the OD matrices. The sub-sections following describe the step-by-step process of O-D estimation.

The transport demand for road-based modes was estimated using O-D estimation process, which required an initial matrix. The initial matrix provided initial values for the traffic flow on the network and hence the algorithm adjusted the matrix in order to provide a closer model flow to the survey.

- **Eighteen Zones -Based Matrix**

The Researcher compared the O-D matrices from different previous studies in order select the appropriate matrix in terms of the total number of trips compared to the actual ones. As a result, the Researcher selected the O-D matrix which was developed in the study of “Strategic Urban Development Master Plan Study for Sustainable Development of the Greater Cairo Region in the Arab Republic of Egypt”, (JICA 2008)

The Researcher used two matrices given in the JICA Study: “Strategic Urban Development Master Plan Study for Sustainable Development of the Greater Cairo Region in the Arab Republic of Egypt (SDMP)”, 2008 for the estimation of all vehicle trips for 2019. The study provided 2008 and 2027 O-D matrices.

- **67 Zones based Matrices**

The Researcher disaggregated the eighteen zones to the current study zoning system (i.e., 30 zones). For this respect, the Researcher used GIS for estimating the current matrix. The process assumed that the trip ends in the SDMP matrix is distributed equally on the area of each zone of the zoning system (i.e., 18 zones).

The process of formulating the initial 2019 O-D matrices for all modes is as follows:

1. The zoning system of JICA study was matched with the zoning system of the current study using GIS. Then, for each zone of the current study, the Researcher calculated the area shared with the JICA zoning system. The current zoning system trip ends were then estimated. The total trip production, attraction, and the O-D pair values for the new zoning system in base year 2019 are generated based on the share proportions with JICA zoning system.
2. The current study zoning system is divided into internal and external zones. The internal zones cover the study area (i.e., 14 zones) while the external zones include the traffic from/to main road penetrating the study area (i.e., Cairo-Ismailia Desert Road) (i.e., 16 zones).
3. Coded each zone and give each one the same name and for each one coded a Population and Employment for 2019 using CAPMAS annual book

- **O-D Estimation Process**

Finally, an iterative process was used in order to adjust the O-D matrices (of the road-based modes) in order to match the traffic counts survey results. For each O-D estimation iteration, the assignment analysis was performed after each trial to ensure the matrix correction flow is approaching the target flow on links. In addition, the O-D matrix for each mode was checked continuously to ensure the O-D pairs were within ±10% of the previous iteration values. The matrix correction trials were terminated when the stopping criteria was met.

The validation criteria used to validate the quality of matching the model volumes and the traffic counts is provided in the Design Manual for Roads and Bridges (DMRB). The criteria stated that the assignment is accepted when 85% of links at count locations have model volumes within ±15% of count volume. In Tables 7 the 24-hours traffic count data on links were estimated using the relation between daily and peak hour traffic (i.e., k-factor).

Table 7
24-Hour Traffic Count Data on Links

Point	DIR	Total Traffic volume in 7 hrs.	Estimated Daily Traffic Volume
G1	DIR1	35452	88475
	DIR2	36114	90127
G2	DIR1	12851	32071
	DIR2	22963	57307
G3	DIR1	19982	49868
	DIR2	24816	61932
G4	DIR1	52941	132121
	DIR2	51594	128760
G5	DIR1	38797	96823
	DIR2	-	-
G6	DIR1	37609	93858

- **Estimation of Daily Traffic Volumes K-Factor**

The Researcher developed k-factor for Greater Cairo depending on historical data which provided the ratio between the daily volume to the maximum hour. Historical data of previous studies was the base for this process, which should be filtrated and verified to select the reasonable k-factor. The Researcher tested several historical traffic data in order to select the most suitable set of data for estimating k-Factor.

The historical traffic count data found in the Feasibility Study of Metro Line 4 was found to be acceptable in terms of accuracy, and sensible among all reviewed studies. In this respect, the traffic volume at each location was used to calculate the k-factor by relating the daily volume to the maximum hour.

Next, the daily traffic volumes at each location were estimated. Then, for each survey location, the maximum hour flow at each hour was found. Furthermore, several ratios were calculated as an average of all survey location. For instant, the maximum hour k-factor was 0.072. In addition, the ratio of traffic volumes in working hours (i.e., from 8:00 to 17:00) to 24-hrs traffic was 0.49.

- **Estimation of Demand Annual Growth Factor**

The methodology of estimating the growth factor which will be used for projecting the Axis and road-based modes demand of 2019 to other modeling years is described below.

The New corridor demand growth factor (GF) is estimated using annual ridership data from 2012 to 2018. The results show that the GF value is around 2.6%.

The Researcher tested the traffic count data from the available studies for GCMA. Then, current study traffic survey data were compared against the selected traffic count data. Finally, the road-based modes Growth Factor was estimated at 5.18%.

- **Traffic Assignment**

Visum software is used to perform traffic assignment based on equilibrium assignment method. In Visum, equilibrium state calculations are formulated as an optimization problem with an objective function and linear secondary conditions. The steps of the equilibrium assignment procedure are illustrated in Figure 8.

Also, the outer iteration checks if there are any new routes with less impedance in the network as a result of its current state. If there is at least one relation, another network state of balance must be calculated. The termination condition applies when the inner iteration step reaches a state of balance and it did not need to shift vehicles to new routes. The gap also can be used as a convergence criterion to terminate the procedure. The procedure of network balancing is illustrated in Figure 9.

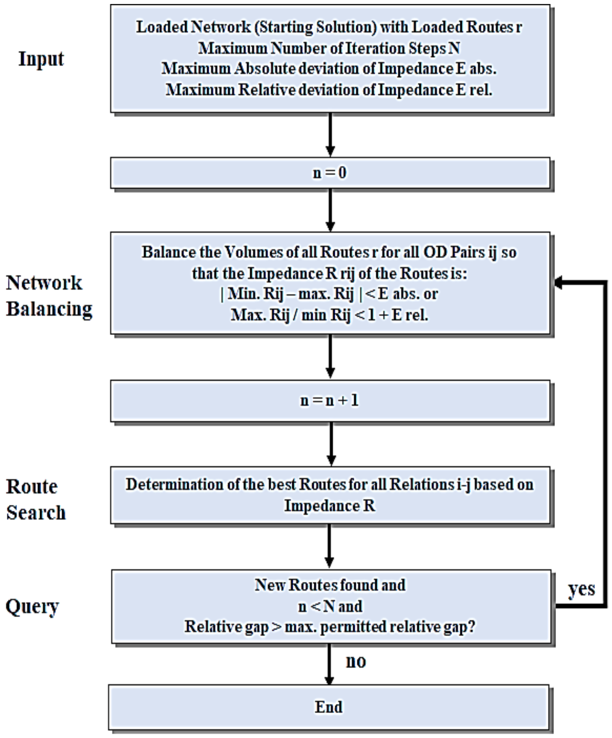

Fig. 8. The Procedure of Equilibrium Assignment

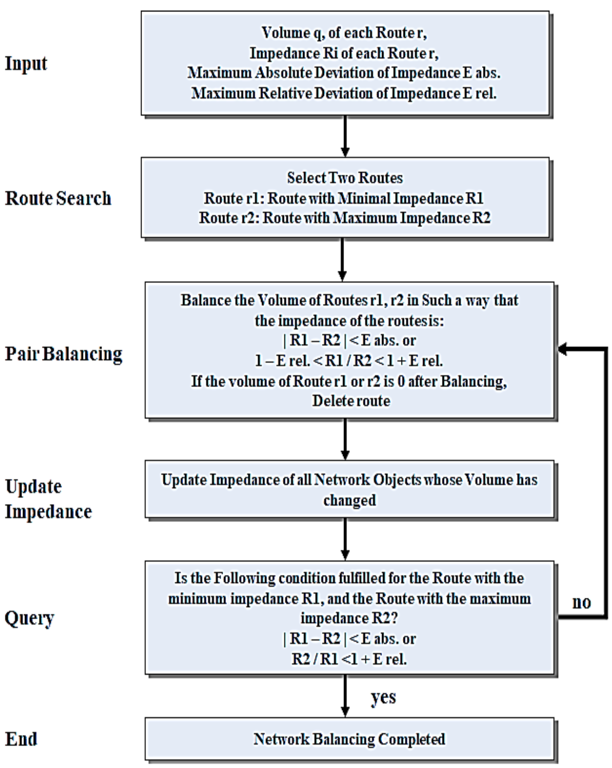

Fig. 9. The Procedure Of Network Balancing For An OD Pair During Equilibrium Assignment (Source: PTV VISUM Manual)

G. Results of Model

- **LOS for Road Based Modes 2019**

As described earlier, the O-D estimation process was used to reach a matrix that provides the accepted model flow. The O-D estimation process requires initial O-D demand matrices to initiate the process. And Estimated Level of Service in 2019 for the With Metro Scenario as shown in figure 10

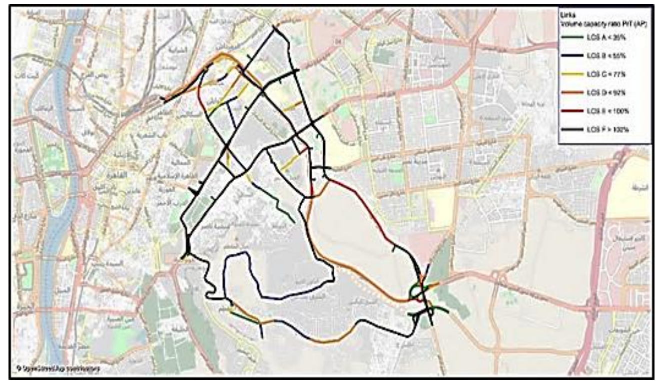

Fig. 10. Estimated Level Of Service In 2019 For The With Metro Scenario

- **The current situation of all intersections and roads**

The Important of intersections were studied in the study area of the current situation using the SIDRA Intersection program. The Researcher found that most intersections at level of service are at the highest degree of danger (F). The following Table 8. shows a summary of the level of service for the most important intersections within the study area, and the Researcher expects that the axis will be withdrawn additional traffic volume from the intersections as shown, which improves traffic on each intersection in the future position.

Also, level of service was studied on the roads, so most of the results were for the axes of the two directions in the current situation in the case of traffic jam and level of service on the roads between D to. F

Table 8
24- Level of service (With /Without) Axis.

Intersection Name	Level of service Without Axis	Level of service With Axis
Ali Amin with Ramses Extension	F	E
The Nasr road with Ramses extension	F	E
Salah Salem intersection with Abbasiya	F	F
Al Tayaran Street with Salah Salem	F	F
Mokattam intersection with Salah Salem	F	F
Amr bin Khattab intersection with Ramses Extension	C	C
Al-Firdaws intersection with Qinsuh	F	E
Nafoura Square	C	C

- **Results of transport models (2024)**

After studying the current situation, the situation was studied for the opening year 2024, and the researcher made the necessary calculations to measure the highest traffic volume and after modeling the study area, the Researcher considered that it is important to compare the daily traffic volumes in the event that the axis does not have to be established and in with axis, to know the impact of the axis on the traffic situation for the opening year 2024.

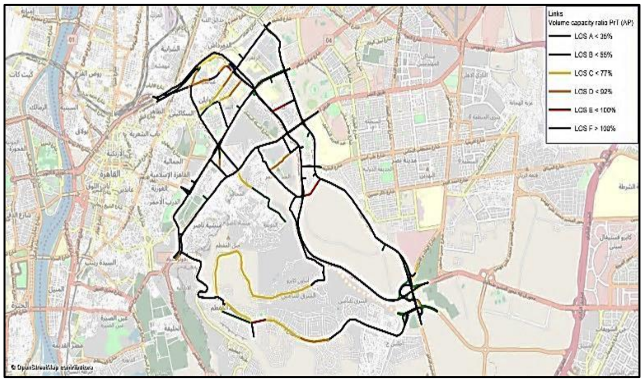

Fig. 12. Level of service on the road network 2043 - Without axis

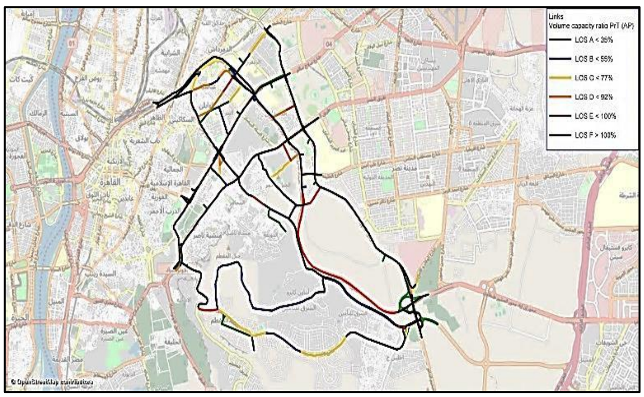

Fig. 13. Level of service on the road network 2024 -With axis

- **Results of the model trip for the year 2043**

After studying the current situation, the situation was studied for the opening year 2043 and making the necessary calculations to measure the highest traffic volume. After modeling the study area, the Researcher considered that it is important to compare the daily traffic volumes in the event that the axis is not to be established and in in case of with axis to be created to know the impact of the axis on the traffic situation for the target year 2043.

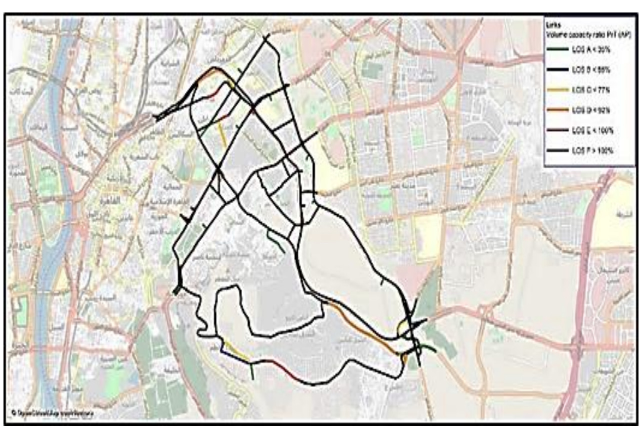

Fig. 14. Level Of Service On The Road Network 2043 -With Axis

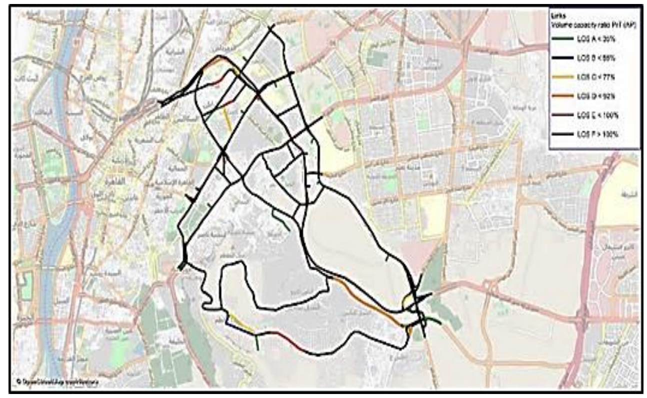

Fig. 14. Level Of Service On The Road Network 2043 -With Axis

VI. SUMMARY & CONCLUSION

This Paper presents the findings of a traffic impact analysis for the project located in Greater Cairo, which is existing to consist of a multi-use building containing surrounding commercial precinct, residential areas surrounding site area retail, restaurant, office, and residential space and schools.

The analysis presented in this paper to supports the major conclusions, In Existing condition Weekday traffic counts were conducted at the study intersections during the AM and PM peak periods, the existing volumes were balanced across proximate traffic count point to reflect a consistent baseline for the volume projections within this paper.

The axis was studied in the traffic area to identify the current situation in the study area, as the study area suffers from severe congestion in the current situation, and that most of the important axes in the study area and intersections with current service levels are between (F, E) and the impact of the axis was studied on the study area in terms of vehicle movement in the current situation is 2019 and target year is 2024.

Modeling was performed for the Full development conditions at the study area during the weekday worst peak PM- peak hours.

Visum was used to model the study area with results based on the Highway Capacity Manual (HCM 2000) methodology. For the purpose of this analysis, it is desirable to achieve a LOS D or better for each approach of all study area . All of the study area network currently operates at capacity and with not acceptable levels of service

But, when coded the axis, the pattern of transport changed and enhance and give better level of service for intersection as mention above.

The importance of the axis and its impact in terms of traffic in the current situation without the axis and in the target year 2043 in terms of traffic for the study area

It will reduce the number of hours of movement for vehicles and journey distances and it will overall improve the level of service for the surface intersections located in the study area for the morning and evening periods.

And it will reduce the delay times on the rest of the road network in the study area, and this w considered an improvement of the existing situation and better also for the target year 2043). Thus, it will reduce traffic congestion in the study area at target year

And the axis itself will remain the level of service on it for all the links for the target year 2043 between (C, D

And the axis itself will improve the level of service on most of the road network in the future 2043

On other hand, based on the results modeling, we can say majority of all road network intersections within the study area currently operate at overall LOS ("E" or better)

The paper gave the possibility:

- To evaluate which, between different considered road network layouts, is the preferable solution that will reduce the hourly covered distance and spent time;
- To choose the road network layout that will maximize the accessibility from the external areas and in the opposite direction.

Based on the overall results of LOS analysis conducted for the Exiting condition and after construction axis , the main conclusions of this paper could be summarized as follows:

The analysis results for the proposed road network indicated an unacceptable LOS E-F on the access roads for majority of road network

- It was revealed from the results from the model that a number of vehicles have switched to using the axle, and this led to a reduction in the total hours spent by the vehicles in the study area daily from 7,524,247 vehicle-hours to 6,734,383 vehicle-hours, or about 11% of the total hours, which is equivalent to 789,864 vehicle-hours per day. This means that the movement times were reduced and speeds improved after adding the axis,

We encourage authors to submit an author statement outlining their individual contributions to the paper using the relevant roles:

1- Conception or design of the work ***(Eng.Ahmed Reda Mohamed** 50% **, Dr.Ahmed Hassan** 20 %**, Dr. Abd El Zaher E. A. Mostafa** 15 % **, Dr.Ahmed AbdELghany** 15 %)*
2- Data collection and tools ***(Eng.Ahmed Reda Mohamed** 100%)*
3- Data analysis and interpretation ***(Eng.Ahmed Reda Mohamed** 80% **- Dr.Ahmed Hassan** 20 %)*
4- Investigation ***(Eng.Ahmed Reda Mohamed** 80% **- Dr. Abd El Zaher E. A. Mostafa** 20 %)*
5- Methodology ***(Eng.Ahmed Reda Mohamed** 70% **- Dr. Ahmed Hassan** 10 % **Dr. Abd El Zaher E. A. Mostafa** 10 % **, Dr.Ahmed AbdELghany** 10 %)*
6- Project administration ***(Eng.Ahmed Reda Mohamed** 55%**- Dr. Ahmed Hassan** 15 % **Dr. Abd El Zaher E. A. Mostafa** 15%**, Dr.Ahmed AbdELghany** 15 %)*
7- Resources ***(Eng.Ahmed Reda Mohamed** 50% **- Dr.Ahmed Hassan** 50 %)*
8- Software ***(Eng.Ahmed Reda Mohamed** 40% **- Dr.Ahmed Hassan** 60 %)*
9- Supervision ***(Dr.Ahmed Hassan** 30 %**, Dr. Abd El Zaher E. A. Mostafa** 35 % **, Dr.Ahmed AbdELghany** 35 %)*
10- Drafting the article ***(Eng.Ahmed Reda Mohamed** 50% **- Dr.Ahmed Hassan** 30 %**, Dr. Abd El Zaher E. A. Mostafa** 10 %**, Dr.Ahmed AbdELghany** 10 %)*
11- Critical revision of the article ***(Eng.Ahmed Reda Mohamed** 50% **- Dr.Ahmed Hassan** 30 %**, Dr. Abd El Zaher E. A. Mostafa** 10 % **, Dr.Ahmed AbdELghany** 10 %)*

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Title Arabic:

تقدير تأثير تطوير تخطيط النقل المقترح حديثًا للمناطق الحضرية المزدحمة بالقاهرة الكبرى
حالة دراسية: محور الفردوس – القاهرة الجديدة

Arabic Abstract:

يتزايد الطلب على النقل في القاهرة بسرعة كبيره، حيث أن منطقه الدراسة جذابة للهجرة و ذلك داخل اقليم القاهره الكبرى. بالإضافة إلى ذلك ، يتم توسيع مساحة مناطق ومجتمعات عمرانيه جديده من خلال التطورات الجديدة مثل القاهرة الجديدة و ٦ اكتوبر الجديده ، مدينة بدر ، مدينه الشيخ زايد.. إلخ وايضا التغيرات العمرانيه التى تشهدها جمهوريه مصر العربيه .

وقد راجع الباحث الرحلات المتولده فى القاهره الكبرى فوجد انه يقدر إجمالي الطلب على النقل في منطقة القاهرة الكبرى (GCMA) من حيث عدد الرحلات الشخصية بنحو ٢٥ مليون رحله في عام ٢٠١٨ JICA 2001- CAPMAS 2018 .

ان نقطه البحث ذات صله وثيقه بالتخطيط الاستراتيجي للنقل من حيث بجوانب محددة حيث لها علاقه بالتحليل المنهجي الشامل لقطاع النقل فى الدوله المصرية ويتم من خلال الباحث اخذ نموذج بحثى فى مجال النقل والمرور ودراسته وهو (محور الفردوس). وحاليا تم تغير اسمه الى محور (جيهان السادات)

لذلك قد قام الباحث بتطبيق علم تخطيط النقل وحركه المركبات فى تقييم للوضع الراهن لشبكه الطرق والتعامل مع المشكلات الخاصه بحركه المرور فضلاً عن الوضع المستقبلي للشبكة المرورية حيث قام الباحث أيضا بتحليل الوضع الراهن للشبكة المرورية و معرفة احجام الحركة المرورية فى الوضعين الحالى والمستقبلى لنموذج النقل التي يتم تصميمه كنموذج بحثى ، كما ان الباحث قام بتحليل تأثير انشاء المحور واكتماله وتطويره على الشبكة المرورية على المستوى الاستراتيجى العام.

حيث كان ومازال، تطوير النقل يتوافق دائما مع النمو الاقتصادي والوضع الاجتماعي للمجتمع .

في هذا البحث ، تم التركيز على دراسة نقليات الحركه ، و سيكون من المفيد إعطاء أهم المؤشرات حول سؤال البحث العلمى المطروح وهو ما هى تاثيرات تطبيق النموذج البحثى على الوضع الحالى للشبكه (وجود المحور / عدم وجوده) ، لذلك تم العمل على النموذج البحثى ، للمحور محل الدراسه حيث يطلق عليه "محور الفردوس" الذى يسمى حاليا محور" جيهان السادات" لذلك؛ سيقوم الباحث بدراسة هذه الحالة بتعمق من حركة المرور والنقل في ، من أجل تقييم الوضع الحالي والمستقبلي لحركه المركبات.