The Effects of Elevated Transportation Infrastructure on the Urban Environment

Examining the Effects of Flyovers on Urban Travel Behavior

A Thesis submitted in the Partial Fulfillment
for the Requirement of the Degree of Master of Science
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I have waited two years for this moment. The moment I write my acknowledgements. I figured; this will be the last thing I will do after finishing up the research. And I was right. Here I am writing the acknowledgement while looking back on all the challenges I faced during this journey and how at the end, I am proud of having been able to overcome them. However, without the support of several people, I would not have been able to arrive at where I am now.

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Abstract

At the moment, mobility approaches in Egypt focus on expanding the road infrastructure between and within cities. With the increasing urban expansion, creating new connections between the different cities and their districts, as well as increasing the capacity of existing ones, became a priority. Consequently, a considerable motion of building flyovers is taking place in Egypt and especially in Cairo. These elevated transportation infrastructures are planned to be a primary tool for solving traffic problems within the cities to enable faster and better mobility of the citizens.

These transportation infrastructures are affecting the urban environment in all its dimensions, environmental, social and physical, including mobility and transportation. Thus, the purpose of this research is to examine these effects, focusing on the impacts on urban travel behavior.

The study is conducted on two scales, one on the macroscale representing the city scale of Cairo and one on the microscale representing the district-scale of Heliopolis. The effects are identified by comparing several aspects between two periods, before the elevated transportation infrastructure construction and after it. Traffic congestion before and after the flyover construction is analyzed using Floating Car Data based visualization analysis to identify the effects of the flyovers on the macroscale. On the microscale, an online travel behavior survey is conducted examining several travel behavior descriptors, such as travel time, trip frequency, mode and route choice etc. to determine the changes influenced by the flyovers. The survey results are analyzed in a qualitative and quantitative approach using statistical analysis models.

Through the analysis on both scales, several changes in the travel behavior due to the flyover construction are identifiable. Some of these changes are contributing to better mobility, such as faster and shorter trips with less congested streets, while others negatively impact the mobility of the community by affecting aspects like mode and route choice, as well as the safety of active travel.
Further research is needed to examine impacts on other urban environment dimensions as well as evaluate these elevated transportation infrastructures as a tool for solving mobility and traffic problems.

Keywords: Flyovers; Mobility; Urban Travel Behavior; Macro and Microscale; Congestion analysis; Travel Behavior Survey; Cairo; Heliopolis; Floating Car Data (FCD); Visualization analysis, Travel Behavior Descriptor

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1. Chapter 1: Introduction

1.1. Problem statement

Currently, mobility approaches in Egypt are centered around constructing new road networks and implementing public transportation projects. Extending the road networks are accompanied with a considerable motion of building flyovers, especially in Cairo. This motion receives a lot of criticism as well as support from the authorities, planners and the community. Consequently, the topic rose high in the currently most debated issues in several fields. Be it the supporting or the opposing point of views; both are built on solid arguments. Nevertheless, it is clear that these infrastructures have an impact on the urban environment, including economic, social as well as environmental aspects in the city. To be able to mitigate the negative impacts and to turn the positive ones into a potential accommodating the needs of the community, and supporting the development of the city, it is essential to understand them clearly.

Unfortunately, the lack of local literature discussing the various impacts of these elevated infrastructures on the Egyptian communities contributes to the continuous construction of those structures without any evaluation or reflection of the previous projects. Thus, the need arose to rethink and reconsider these massive structures, even if only through analyzing and understanding their impact on the different urban environment dimensions.

Only then, better information can be provided for adequate decision-making processes, achieving better urban planning, management and development. Understanding the various impacts and how they differ from one place to another, trying to mitigate the negative ones, can turn into a potential for future city planning.

In this research, I want to identify the impacts of such elevated transport infrastructures on the urban environment and to examine their influence on the urban travel behavior on the macro and microscale in Cairo. The analysis done in this research aims to build a base for the evaluation and development of this topic in future research, contributing to the local literature in this field.

1.2. Aim and objectives

This research aims to examine the effects of elevated transportation infrastructure on the urban environment.

Transportation infrastructure consists of any fixed installations related to transportation, such as canals, waterways, railways, roads, terminals, bus stations, railway stations and airports (Hossain, 2019). Elevated transportation infrastructure represents the types of transportation infrastructure that is elevated from the ground, such as elevated railways, elevated roads, and bridges.

In this thesis, the main focus is on the transportation infrastructure of roads, more specifically elevated roads, such as flyovers.

The urban environment is a term that has various definitions in different sciences and schools. In this thesis, the term urban environment is used to represent the social practices and actions that take place in an urban realm (Sénécal, 2007). It also describes the resources (human and natural), processes (transportation, construction, etc.) and the effects of these processes (positive and negative) in urban areas, which consists of three dimensions; natural, socio-economic and built environment (Sabu and Ambat, 2015).

The research has three main objectives:

1. **To examine the effects of the elevated transportation infrastructure (ETI) on urban travel behavior on the macro and microscale**

These effects will be examined on urban travel behavior changes, which includes changes in congestion, traffic flow or travel behavior of people on two scales. The city-level being Cairo and the district level being Heliopolis district, which is chosen as the case study area. The researcher chose to examine the effects of the ETI on two scales to analyze the situation from two different viewpoints, seeking a deeper understanding of the topic and the magnitude of ETI effects on the urban environment.

2. **To examine the effects of the ETI on the congestion and traffic flow of Cairo**

The congestion and traffic flow changes will be examined before and after the ETI construction to identify the possible effects leading to travel behavior changes of the society on the city level. Potential changes in peak times, travel time and congestion choke points will be analyzed.

3. **To examine the short-term effects of the ETI on the travel behavior of Heliopolis residents, visitors, and workers**

The travel behavior will be examined before and after the ETI construction to identify the possible effects leading to short-term travel behavior changes, including changes in route, destination and mode choice, trip frequency, chaining, distance, and time, of the residents, visitors and workers of the Heliopolis District

1.3.Scope and limitations

The scope of this research is limited to the objectives above. Due to the limitation in time and resources, only one type of elevated transportation infrastructure is examined, which is the flyovers.

The case study chosen for this research is Heliopolis in Cairo. Furthermore, several flyovers in the study area were selected to be studied. Reasons behind selecting the case study and the specific flyovers are explained in Chapter 6.

Because only one case study was chosen for this research, the effects identified and examined are only representing a sample of the ETI effects on the urban environment and might not be eligible for generalization.

In addition to limiting the scope to one ETI type and choosing one study area, the research only concentrates on the effects on the urban travel behavior as part of the urban environment. Other effects on the urban environment are being discussed in the literature review chapters through representing international and local literature addressing this topic.

One of the main limitations of the research is the pandemic of COVID-19. The pandemic affected the approach and methodology of the research due to the restriction of conducting fieldwork, such as mapping, observations and on-ground surveys and interviews. Moreover, any data gathered post the pandemic represents a particular state, due to the change in travel behavior during the pandemic on the macro and microscale. To try and mitigate this error, the data collection on the microscale was specific to the period before the pandemic. However, the period between the end of ETI construction and the beginning of the pandemic is roughly two months.

For the macroscale, the data of the pandemic phase was included in the analysis, due to the nature of the available analysis tool. As a result of the pandemic consequences and the limited timeframe, the macroscale analysis was conducted before having complete data on the selected ETIs. Further details on the specific limitations are discussed later in the thesis.

1.4.Conceptual Framework

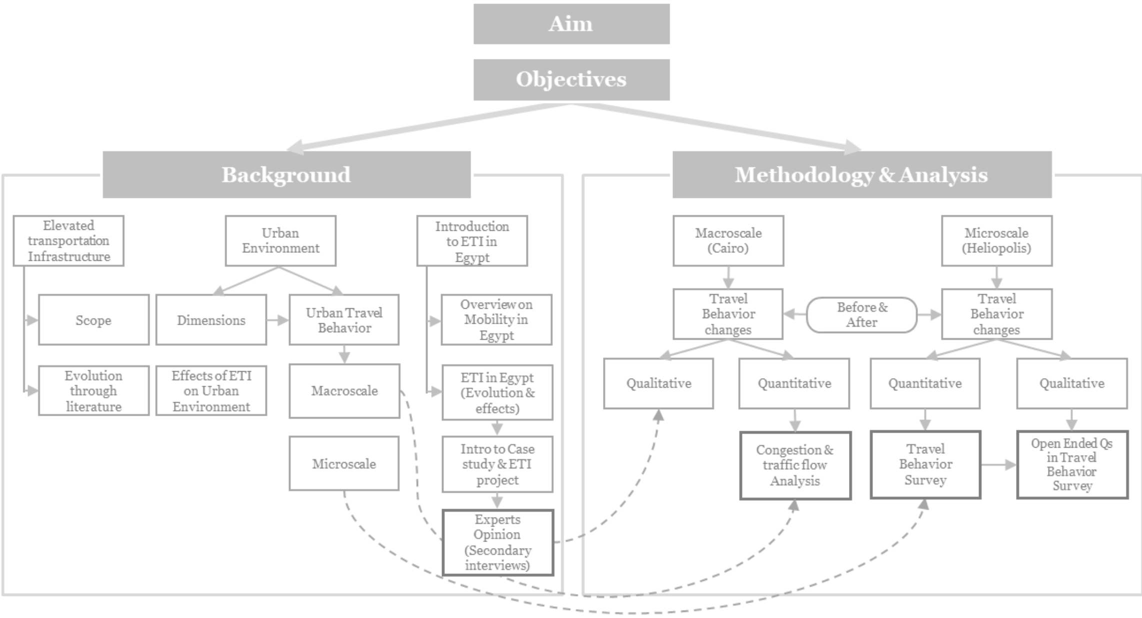


Figure 1: Conceptual Framework Diagram

The research is mainly divided into two main parts, the first consisting of the secondary data represented in the background needed to understand the topic, and the second one is about the primary data produced through the methodology and analysis.

The background includes international resources addressing the topic of elevated and at-grade road infrastructures and their effects and impacts on cities, through the review of different literature. It also includes definitions and descriptions of important terminologies and concepts such as the urban environment and the urban travel behavior. Moreover, several methods and analysis approaches conducted through international empirical studies to measure travel behavior are represented.

Local literature about mobility in Egypt and Cairo, in addition to the motion of constructing ETI in the local context is also addressed in the background part.

Furthermore, a background about the case study of Heliopolis and the traffic development project is being discussed.

The knowledge gathered from the background is transferred into the primary research, especially in the methods and tools used to conduct the data collection and analysis.
The methodology and analysis part is done in two scales, the macro and microscale. Each scale analyzes the state before the ETI construction and after it to be able to compare both states and identify the potential effects and changes. The macroscale is focusing on travel behavior by analyzing traffic congestion and flow. In contrast, the microscale is focusing on the changes in the individual travel behavior of ETI users.

2. Chapter 2: Elevated Transportation Infrastructure

This chapter is the first part of the literature review. It discusses the main terminologies used to describe transportation infrastructures, in this case, road infrastructures, to set the scope for the literature review and the rest of the research. It also represents the change in perspective of the road infrastructure throughout time, from the very start when (elevated) highways were seen as a form of development, till the time were planners and politicians realized its negative impacts and effects.

2.1. Introduction and scope

In the field of transportation infrastructure, there are a lot of terms being used interchangeably, due to the close similarity between these terms and infrastructures. Terminologies like highways, expressways, freeways are often used to describe the same infrastructure. Also, terms like bridges, flyovers, overpasses, and elevated highways are used in an interchangeable matter.

So, in order to identify which exact term we are using to describe the studied infrastructure, a clear definition needs to be made.

Transportation infrastructure

Highways are defined as main roads connecting major cities and towns (Oxford Dictionaries). Vehicles can enter the highway through ramps or intersections.

Freeways are controlled-access highways without any intersections. It is called freeway as it is free from traffic lights, at-grade crossings, and intersections. This makes freeways faster compared to regular highways. Vehicles access the freeway through ramps. (Hellinga and Van Aerde, 1994; Kweon and Lim, 2014)

Expressways are controlled-access highways with at-grade, signalized intersections. Vehicles can enter only through specific entry and exit points limited in number, allowing vehicles to drive at a higher speed. (Dietz, 2017)

Elevated transportation infrastructure

The difference between bridge and flyover or overpass depends on the function and location of the structure.

A bridge is a general term used to describe a structure built to connect two locations separated by natural obstructions, such as rivers, valleys, etc. (Doc, 2014; Maratha, 2017)

Flyovers or overpass are structures which are built over human-made obstructions, such as roads, intersections etc. to overpass congestion for faster mobility. As the name implies, flying over a traffic zone. (Doc, 2014; Maratha, 2017)

In this research, the focus is on flyovers, used to solve the traffic congestions accruing in the intersection of streets.

Freeways, which are a type of highways, and flyovers are two sides of the same coin. In most cases both occur together, as to create a freeway, intersections need to be eliminated, and the most common approach is through flyovers.

Due to the limited literature on flyovers, in this literature review, highways and freeways are included in the research. All these infrastructures might differ in specific characteristics but are closely connected when it comes to the impacts and effects on the urban environment. They are also almost treated the same when it comes to urban policy and planning, in the past and in the future.

2.2. Evolution of (elevated) transportation infrastructure through time in literature

(Elevated) highways were once perceived as the tool for better mobility, enabling fast connectivity between several areas. They were seen as a sign of urban development and modernization. However, with time, the negative impacts and effects of those infrastructures came to the foreground, which turned the enthusiasm to doubt and criticism.

This shift in perception can be clearly traced through literature, starting from the reason behind introducing such infrastructure and their benefits, to the reasons behind why these structures need to be rethought or deconstructed due to their negative impacts on the urban environment, such as mobility, health, economy, environment and society.

Reasons behind ETI

While today, urban planners are calling to remove highways and bridges from cities, in the past urban planners are the ones who encouraged the construction of such infrastructures to act as a mobility solution.

The rationale behind it was to separate the car mobility from the city, avoiding traffic, accidents and pollution, while maximizing the potential of the motor cars.

MacKaye and Mumford (1931) looked at the highways as a proper way to enable the use of cars. For them, the problem started when private vehicles slowly made their way in society, without having adequate well-thought infrastructures to accommodate them. Hence, the cars drove on the roads where the carriages once moved in. This created traffic for car users and unsafety for pedestrians. To enable proper use of cars, it needs to be seen as a whole system, as the locomotive system (Mackaye and Mumford, 1931). While introducing the railroad, an entire independent system of transportation was planned and constructed. New roadbeds were specialized, a right of way was created, terminals and stations were constructed etc. Based on MacKaye and Mumford (1931), this should give a clue about the proper treatment of the car transportation system. It needs to be an independent system laid down to bring the maximum potential advantage of the automobile.

To create a system accommodating the use of cars while keeping the cities free from traffic, pollution, and accidents, townless highways should be constructed (Mackaye and Mumford, 1931). These highways avoid passing through towns while being provided with enough land on both sides to act as a buffer between the highway and the surrounding area, be it rural or urban.

For the motorcar system to resemble more the railroad, MacKaye and Mumford propose keeping the road absolutely free. Unlike the railways, highways enable car users to take their own decision when and where to get off the highway. This creates unsafe situations caused by driving through intersections and split roads. To solve this problem, it should be impossible to enter or depart from the highway except at points which are properly planned (Mackaye and Mumford, 1931). This system was named by Chairman Edward Bassett, the National Council on City Planning, as a "freeway" (Bassett, 1930). The freeway concept creates a highway with less intersection, through constructing overpasses or underpasses to eliminate the intersections.

When the motorcars started pouring in the streets initially designed for wagons, carriages and pedestrians, the traffic congestion increased immensely. Before, expanding the railway was seen as a solution to this problem (Bauman, 1991).

In the 1930s, the mass transit services were declining, as people preferred the privacy, convenience and flexibility of motorcars (Mohl, 2002). By 1944, the focus was shifted from railways development to constructing a solution in favor of the automobile industry (Bauman, 1991).

Looking at the first era of highway planning between the forties and fifties, Bauman (1991) sheds light on the pro-growth coalition created in America. This coalition consisted of city planners, downtown-based businessmen and civic leaders. They believed in urban survival through the rebuilding of the downtown, which included a modern highway system. This highway system would revitalize the urban cores by reducing the traffic jamming the city streets through channeling the motorcars and vehicles outside of the downtown areas (Bauman, 1991).

The accordingly freely accessible downtown would create a healthy urban residential environment and would revitalize the urban economic health. These beliefs drove highway planning in the period before 1956 (Bauman, 1991).

Any obstacles, such as parks, historic canal structures, etc., in the way of achieving the goal of linking the cities through highways, had a secondary priority. At that time, highways were seen as the latest, most visible symbol of urban progress (Bauman, 1991).

Later on, city planners saw highways as an opportunity to speed the redevelopment of cities, raise property values and limit the spread of slums. City planners, like Robert Moses, looked at highways as the solution for most urban problems. He believed highways needed to cut through cities to provide better mobility, solve traffic problems as well as upgrade the surrounding urban areas (Mohl, 2002).

Others, like Paul Oppermann, the planning director of San Francisco, publicly announced in a speech in 1950, that highways are going to be the urban backbone of cities. These highways are separating cities into logical areas, like residential and business districts, while linking different areas of the cities with fast, accessible roads.

The concept of linking urban highways and urban housing and planning originated in the Bureau of Public Roads (BPR), established in 1919. Thomas H.

MacDonald, a highway engineer and the head of the BPR, promoted this linkage, highlighting the need for modernization and reconstruction of American cities (Mohl, 2002). He and Robert Moses created a long campaign to promote urban highways, arguing that they will provide an opportunity to remove central-city slums and to rebuild an urban core following modern standards.

Following this concept, starting late 1950s and going into the 1960s, highways construction in America was associated with massive family dislocation and housing deconstruction. The historical record showed that slum clearance, urban redevelopment and highways were closely related in the postwar urban policymaking (Mohl, 2002).

Over the course of years, highway engineers developed their vision of technologically efficient freeways, speeding vehicles to their destinations, by-passing the vast traffic jams clogging the roads of downtown. Ironically, instead of reviving central cities and downtowns, like expected from the city planners, the new freeways speeded the suburbanization process. Consequently, a process of decentralization of retail and manufacturing took place, putting the central cities through an urban decline (Mohl, 2002).

Criticism of ETI

After being one of the supporters of constructing highways, Mumford came back in the 1960s to alert on the damage done by them.

Mumford highlights how the life of people does not depend on motorcar transportation but on the "religion of the motorcar" (Mumford, 1963) The result of the overdependency on the cars is that motorcars actually got crippled. The huge burden of being the sole means of transport for every kind of travel can be taken by neither the vehicles nor the infrastructure itself, which will eventually destroy the cities. According to Mumford (1963), a good transportation system minimizes unnecessary travel, while giving several options of speed and mode change to accommodate the diversity of human needs and purposes.

The newly constructed highways serve cities that are already congested within. However, building these highways results in tempting public transport users to use the new private facilities to reach urban centers, thus creating more congestion (Mumford, 1963).

Furthermore, Mumford compares the elevated railways with the newly constructed elevated highways. In mid- 1900s, elevated railway systems were a new method of introducing a new type of rapid transportation system through the American cities. Later, the negative impacts rose in the noise and overshadowing of the structures, which decreased the property values in the surrounding areas. The area beneath the structures became dangerous and could not be used anyways. Ironically, the destruction of the old elevated railways in New York was met with a triumph at the same time elevated highways were constructed in the city, repeating the same error again (Mumford, 1963).

Although mass transit transports in less space at least ten times more people per hour than private cars, all funds are poured into highway construction and development. Hence, leaving the most important modes, railways for long-distances, and subways for short distances, to deteriorate and eventually disappear (Mumford, 1963).

In 1966, the American architect Lawrence Halprin highlighted how the elevated freeways negatively impact the neighborhood they pass through:

"Elevated freeways have done even worse damage to the areas through which they pass. They have blocked out light and air; they have brought blight into the city through their great shadows on the ground and through the noise of their traffic. Worse still, the surfaces under them have been devoted to parking lots, automobile junkyards, cyclone fences, and rubbish. These elements more surely than the freeway itself have gone far to uglify the cities through which it passes." (Halprin, 1966)

In the early 1960s, Jane Jacob challenged in her book "The Death and Life of Great American Cities", urban renewal and urban highways. Jacobs discussed the impact of highways on both the society and the built environment, stating "expressways eviscerate cities" (Jacobs, 1961). She highlighted the unintended consequences of urban highways, such as land use impacts, displaced communities, death of pedestrian life and environmental degradation. For her, cities should priorities social interaction at street level, encourage walking, riding bikes and public transportation so people can interact with each other.

In the report "The Life and Death of Urban Highways" (ITDP and EMBARQ, 2012), Peter J. Park discussed in his foreword that freeways are the wrong design solution for cities. Freeways rely on minimizing the interruptions and limiting the access while maximizing the traffic flow. However, cities consist of connected street networks, when cut by freeways, barriers affecting vitality are being created (ITDP and EMBARQ, 2012).

The main purpose of a transportation system within a city is to connect and move people to places. When freeways are force-fit into the urban neighborhoods the main priority becomes moving vehicles through and away from the city. In Park's opinion "The freeway in the city was an untested idea when it was deployed around the world. Decades of failing to deliver congestion relief and improve safety combined with the hard evidence of damaged neighborhoods have proven that the urban highway is a failed experiment." (ITDP and EMBARQ, 2012).

Albert Saiz (2006) made several links between highway construction and dictatorship. He argues that four theories are linking both together (Saiz, 2006). First, dictatorial governments see the investment in the infrastructure as a way to enhance the image of the regime and sometimes to extract money through rents or corruption. The second one, democratic countries are more prone to enhance the welfare of citizens and redistribution, giving them a higher priority than any other infrastructure construction. The third theory is related to keeping a good road network for external military interventions as well as internal repression. Lastly, electoral competition may push them to give priority to achieving new projects and construction rather than keeping maintenance of old projects.

Seventy years is the average lifespan of elevated highways (NDT Resource Center, n.d.). Since these infrastructures started during the forties, a lot of them are approaching their obsolescence. Many decision-makers around the world tend to reduce the maintenance budget in order to invest more in building new infrastructure that would link their names to these new achievements, thus leaving the old structures to decay (Jaffe, 2015). Other cities took this opportunity to rethink the urban highways, whether they are worth further investing in or they should be removed. As a result, some urban highways are being torn down or changed into boulevards. There are several case studies around the world, advocating the positive effects of removing highways and turning the space into places the city can benefit from.

Induced demand

Highways and especially freeways are typically built as a solution for congestion or to increase traffic flow. Several studies throughout years have shown that highways do not alleviate congestion (ITDP and EMBARQ, 2012). Expanding the road capacity might provide congestion relief at the beginning; however, later on, it is likely to have an opposite effect, even within the first five years (Duranton and Turner, 2011). On average half or all of the saved time will be "ploughed back into more, or longer distance, travel, which erodes the benefits and creeps back- sometimes rushes back- towards the condition of the congestion observed before." (Choi et al., 2014)

The theory of induced demand was also explained by Carvero in 2003. Building more and expanding highways induces the demand for constructing even more highways. The reason behind this is that new highways encourage people to shift from public transport to private cars, as well as creating new and longer trips, which all result into creating more traffic flow and therefore eventually congestion (Cervero, 2003).

Traffic engineers from the US and UK observed by the late 1960s that adding road capacity did not decrease travel times. In their opinion, this was due to the additional trips induced because of the new highways. Ever since, several studies highlight that new road capacity usually induces traffic in a direct proportion to the amount of new road space built so does removing road space reduce the traffic (Cairns et al., 2002). Some studies show that in most cases the traffic levels went down on those streets where the capacity got reduced, sometimes reappearing in the neighboring ones (Choi et al., 2014)

This phenomenon was studied in a report, called "Disappearing traffic? The story so far" (2002), examining 70 cases over eleven countries, as well as the opinions of 200 transport professionals. The report discussed the reallocation of road space from general traffic to improve the quality of active travel infrastructure or public transport systems and if this reallocation would result in the increase or decrease of the congestion levels on those roads. The study suggests that the prediction of the traffic situation after removal of road space are often unnecessarily alarmist (Cairns et al., 2002). On the contrary, given the appropriate circumstances, significant travel level reduction may occur. This is a result of people making a wider and more complex range of behavioral responses than it is always assumed (Figure 2).

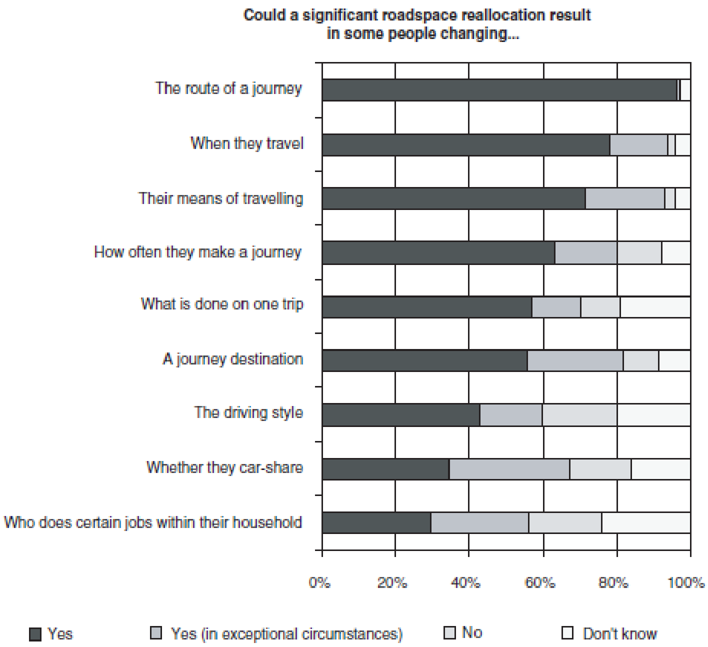


Figure 2: Professional opinions about plausible behavioral responses to a change in road conditions (Cairns et al., 2002)

According to the cases studied in this report, an average of 11% of traffic level reduction can be seen across the various treated areas or roads, as seen in Figure 3 (Cairns et al., 2002).

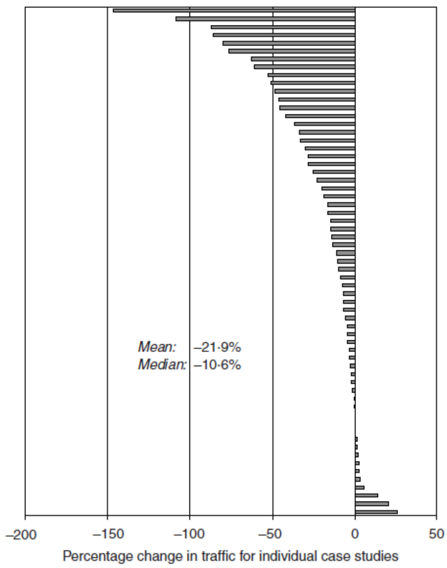


Figure 3: Distribution of recorded changes in traffic levels for individual case studies (Cairns et al., 2002)

In conclusion, transportation infrastructures and roads have several types and forms. In the past, they were perceived as a tool for better mobility, enabling fast connectivity between several areas and eliminating congestion and accidents within the cities. They were seen as a sign of urban development and modernization. With time, their negative impacts and effects started to appear, turning the enthusiasm into criticism. The impacts of such infrastructures can be seen in several aspects of the cities, such as mobility, health, economy, environment and society. In this chapter, this shift in perception was discussed by presenting different worldwide literature.

In the next chapter, the dimensions of the urban environment will be defined. Moreover, the effects, mentioned in worldwide literature, of those infrastructures on the different urban environment dimensions will be discussed.

3. Chapter 3: Urban Environment

Various disciplines and schools have contributed to the emergence of the concept of the urban environment. Its first appearance was within the context of urban and land use planning. At the end of the nineteenth century, this was the point of concern for reformists, hygienists, and utopian planning movements, which influenced how the cities were built (Berdoulay et al., 2002) in (Sénécal, 2007).

To capture the full meaning of the urban environment, Beatley and Wheeler (2004) assumed that the urban environment is connected with sustainable urban development and traced the concept's origins by going through the work of Ebenezer Howard (1898), Jane Jacobs (1961), Ian McHarg (1969). Their work focuses on transportation, architecture, urban planning, restoration of urban areas and plant ecology. It also includes issues about environmental equity and social and economic aspects (Beatley and Wheeler, 2004) in (Sénécal, 2007).

Due to the diverse sector involved in the urban environment concept, there are several explanations and dimensions to this term. It is often considered by researchers to understand the social practices and actions happening in the urban realm, however also associated with the natural elements of the surrounding environment (Sénécal, 2007). It can also be pointing to the ways the society is organized, and the surroundings are shaped. "To paraphrase William Cronon (1996), the urban environment can thus be seen as a set of entangled social facts and states of nature." (Sénécal, 2007)

3.1. Urban environment Dimensions

Like the term definition, the dimensions of the urban environment vary from sector to sector and researcher to researcher. According to Danielle C. Ompad, Sandro Galea, and David Vlahov (2007), the urban environment is divided into three main concepts, social environment, physical environment, and urban resource infrastructure.

The social environment describes the interpersonal relationships and interactions between urban communities and individuals, as well as the collective values and norms shared by them (Coutts & Kawachi, 2006) in (Ompad et al., 2007).

The physical environment is considered the built environment. The built environment includes "housing form, roads and footpaths, transport networks, shops, markets, parks and other public amenities, and the disposition of public space" (Weich et al., 2001) in (Ompad et al., 2007).

The urban resources infrastructure includes social and health services as well as municipal structures such as law enforcement, shaped by national and international policies and regulations. (Ompad et al., 2007)

Based on the urban environment division explained by Dr. T. Sabu and Dr. Babu Ambat (2015), the urban environment has three dimensions as well.

The first dimension is the natural environment consisting of human beings, water, land, minerals etc. The second dimension represents the socio-economic environment. This dimension consists of human activities, health, education, culture, urban lifestyles, as well as economic and business activities. The last dimension is the built environment which includes housing, roads, railways, water, gas, electricity supply (Sabu and Ambat, 2015).

Within each dimension the urban environment components are divided into resources, which include human and other natural resources, processes, converting these resources into various usable outputs, and effects, which represent the effects of these processes. Several examples of these components are shown in the table (Sabu and Ambat, 2015).

Resources	Process	Effect
• Human resources • Sunlight • Land • Water • Minerals • Electricity • Fuels • Finance • Intermediary products • Recyclable materials etc.	• Manufacture • Transportation • Construction • Migration • Population growth • Residence/Living • Community Services (education, Health etc.)	• ***Negative*** Pollution (air, noise, soil, water), Waste generation (garbage, sew-age congestion, overcrowding etc.) • ***Positive*** Products, Value addition, Increased knowledgebase/educa-tion, Access to Better Services)

Table 1: Components of Urban Environment (UMERI Website)

3.2. Effects of ETI on the urban environment

Further impacts of the highways were discussed by Mary Ebeling in 2012. She presents several impacts on the mobility of people, the environment, the society and their health and the economy.

While highways might be a good solution for moving high volumes of people for a long-distance, they disturb the street grid of neighborhoods, acting as barriers between the community and their main destinations like education, employment, and commercial ones (Ebeling, 2013; ITDP and EMBARQ, 2012).

Being elevated brings other aspects into the picture. They create safety hazards for travellers, especially non-motorized travellers, who often do not know how to navigate around the elevated infrastructures. The area beneath the infrastructure also poses a threat to their safety through undesirable or criminal activities that are hidden by these dark spaces (Khaleghi and Pakzad, 2017).

Socially, these infrastructures do have a record of doing various damages to neighborhoods while being constructed. Most of the decision-makers choose the cheapest land with the least powerful opponent to build the highways; thus, a lot of poor neighborhoods were destroyed and cut off from each other and services (Ebeling, 2013; Schindler, 2015).

Another serious impact of the highways is the impact on the health of society. The increased emission in the near proximity to the highways results in increased air pollution, which affects the rate of asthma disease as well as cardiovascular diseases (Ebeling, 2013; Levin, 2012). Studies found that the risk of low birth weight and preterm birth is dramatically increased when pregnant women live closer to highways (Miranda et al., 2013).

Besides air pollution, highways contribute to the production of ground-level ozone, putting additional strain on the health of people. In addition to that, they increase the temperatures in their surroundings through the heat island effect, making heat waves more severe (Ibrahim Siti Halipah et al., 2018).

Although highways provide vehicular access to downtowns, they lift the accessibility for the local commercial activities in downtown areas (Ebeling, 2013). People driving on a highway through the city have limited opportunity to vitalize local businesses. Thus, the commercial activity which shifted from the downtown areas to outside the city boundaries is accessible mainly through cars without being integrated into the neighborhoods. This is also contributing to the suburbanization and the increase in urban sprawl (Ebeling, 2013).

Besides the enormous cost of constructing and maintaining the highways, another economic impact is the highways occupancy of valuable land without contributing to taxes, as well as its effect on the property value of the land surrounding these heavy structures (Carey and Semmens, 2003).

Concluding, the urban environment is a term that has various definitions in different sciences and schools. The term urban environment is used to represent the social practices and actions that take place in an urban realm (Sénécal, 2007). It also describes the resources (human and natural), processes (transportation, construction, etc.) and the effects of these processes (positive and negative) in urban areas. The urban environment dimensions consist of three dimensions; natural, socio-economic and built environment (Sabu & Ambat, 2015) or social and physical environment and urban resources infrastructure (Danielle C. Ompad, Sandro Galea, and David Vlahov).

During this chapter, the different effects of transportation infrastructures are presented. The roads infrastructures have impacts on the social aspects, such as segregation and increasing the feeling of unsafety. Effects on the environment include pollution and health hazards, while on the economic aspects, the effects include a decrease in land and property value.

Based on the definition and dimensions of the urban environment discussed in this chapter, mobility and transportation is part of the physical or built environment. In the following chapter, urban travel behavior is discussed as part of the mobility aspects being affected by transportation infrastructures.

4. Chapter 4: Urban Travel Behavior

This chapter discusses the urban travel behavior, as part of analyzing mobility and transportation patterns. The chapter presents different analysis approaches discussed in the literature to measure the travel behavior changes on the macro and microscale.

Transportation planning requires analysis, modelling and simulation of the performance and use of transportation infrastructures and systems. The main goal is to implement infrastructure or systems that meet the needs of the people in terms of mobility, while also introducing policies to improve sustainability. To be able to achieve that, human behavior needs to be understood and analyzed.

The origin of travel behavior analysis can be traced back to 1950s. This period witnessed rapid motorization of major US cities, the development of a legislative framework guiding transportation planning and the creation of a "rational" planning process as required for the receipt of the federal fund (Weiner,2012) in (Goulias, 2016). In Europe, a similar development took place by conducting traffic studies as a result of the technology transfer from the US.

(Jones,2012) in (Goulias, 2016). These studies aimed at examining the impacts of the motorization and changes in land development on the traffic flow and trip making. Simulation of traffic in cities using mathematical models based on population travel behavior was created. Collecting travel behavior data was also motivated by the need to develop forecasting models to enable the planning of new roads and how these roads and their location might influence the city.

Changes in travel behavior occur with the changes in transportation systems and social settings, transportation systems including transportation infrastructure and services, social settings including changes in social and institutional circumstances (Choi et al., 2014). Identifying the travel behavior changes associated with one of those major changes is the basis of policy instruments. The success of any policy input in the field of transportation is to assess the individual response to this policy measure before and after the implementation of the measure (Choi et al., 2014).

Policy initiatives in the transportation field, whether providing improved infrastructure, services, or management, either provide capacity for demand growth or reduce this growth. Such initiatives can be the introduction of Park and Ride services, which sometimes generates a complex behavior response (Choi et al., 2014). It can also be the change in prices and fares, which is a dimensionless constant that can be interpreted in terms of elasticity, for example, an elasticity of -0.5 means that if prices go up 10%, the demand will decrease by 5%. Car ownership and traffic, as well as soft factor policies, also affect travel behavior (Choi et al., 2014). Soft factor policies represent the quality of transportation alternatives and the information and perceptions people have about them. Several policies aim to alter the quality of alternatives and people's perception about them to achieve a specific goal. One of the most visible initiatives is building roads, increasing their capacity or reducing it.

When building or increasing the capacity of roads, usually a case of induced traffic occurs, as discussed in Chapter 2.

As mentioned before, travel behavior is likely to change when changes happen in the transportation systems and services, such as changes in the congestion and travel type due to change in the road infrastructure. Travellers' responses to network changes may differ according to the spatial occupancy and temporal duration of the network changes (Dowling and Colman, 1995). Closure of a local street within a neighborhood may not require travel behavior changes for most of the commuters, while a closure in a major highway might (Carrion and Levinson, 2011).

Travel behavior change is complex and appears over the short and long term. The short-term changes might appear in the route choice, mode choice, trip frequency, time of day the trip is made, trip chaining and destination choice (Carrion and Levinson, 2011; Goulias, 2016). The longer-term impacts would appear in the car ownership, residential locations, land development patterns and the choice of work location (Dowling and Colman, 1995). All these changes occur along demographic and economic changes affecting the population (Carrion and Levinson, 2011).

4.1. Urban Travel Behavior on the Macroscale

Gathering knowledge and understanding the traffic changes and travel patterns in a city is crucial to be able to quantify the effects of the transportation improvements and proposed projects. One way of understanding traffic performances is by analyzing traffic congestion and flow. When measuring congestion, the definition of this state is important. However, there is no single, broadly accepted definition of traffic congestion (Dzintars and Sutton, 2018). One of the reasons behind this is that congestion can be perceived as a physical and a relative phenomenon. The physical one is related to the fact of vehicles hindering the movement of others as demand for limited road space. The relative one describes the user expectations about road system performance. Both phenomena are important to understand the congestion and its reasons and impacts (Dzintars and Sutton, 2018).

COMMON INDICATORS TO MEASURE CONGESTION			
Indicator	Description	Comprehensive?	Multi-Modal?
Roadway LOS	Congestion intensity at a particular location	No	No
Multi-modal LOS	Congestion delays to various modes, rated A to F	No	Yes
Travel time index	Ratio of peak period to free-flow speeds	No	No
Average Traffic Speed	Average vehicle traffic speeds at a particular location	No	Yes if for all modes
Commute Duration	Average time per commute trip	No	Yes if for all modes
Per capita travel time	Total average time residents devote to travel	Yes if for all modes	Yes if for all modes
Percent travel time in congested conditions	Portion of peak-period vehicle congestion that occurs under congested conditions	No	Yes if for all modes
Congestion duration	Average duration of congested conditions	No	No
Congested Lane Miles	Number of lane-miles congested during peak periods	No	No
Annual hours of delay	Hours of extra travel time due to congestion	Yes if for all modes	Yes if for all modes
Annual delay per capita	Hours of extra travel time divided by area population	Yes if for all modes	Yes if for all modes
Excess fuel consumption	Total additional fuel consumption due to congestion	No	No
Congestion cost per capita	Hours of delay times monetized value of travel time, plus additional fuel costs, divided by area population	Yes	Yes if for all modes
Planning Time Index	Earlier departure required when traveling during peak periods	No	No
Barrier effect	Walking and cycling delay caused by wider roads	No	No

Table 2: Common Indicators to measure Congestion (Dzintars and Sutton, 2018).

Like its variety of definitions, the indicators measuring congestions vary as well (Table 2). One of those indicators is traffic speed and travel time (Dzintars and Sutton, 2018).

There are several techniques to gather traffic data. The usual methods include traffic reports on Traffic Message Channels (TMCs) received by navigation devices (Jeske, 2013). These TMCs receive their data from permanently fixed sensors, such as traffic cameras or inductive loops, volunteers, and the police. Nevertheless, these traffic reports are often out of date when processed by these navigation devices. They are also to an extent edited by humans and are not automatically generated nor sent (Jeske, 2013).

Other methods are traffic monitoring systems using stationary detectors. However, these systems do not produce reliable data about travel times within a network, due to their low density in urban areas as well as the high disturbances in those areas (Gühnemann et al., 2004). That is why they cannot produce velocity profiles which are needed to process travel times. To overcome this, other techniques such as physical sensors, license plate recognition, airborne traffic measurement, infrared and laser vehicle detection and video imaging are being used (Gühnemann et al., 2004).

However, these techniques have several shortcomings. The permanently installed sensors are not always sufficiently distributed over the city area, as their installation and maintenance are expensive (Ajmar et al., 2019). They also usually fixed over main roads, which makes it impossible to analyze data from secondary or local roads. This limits the collective analysis of a city as a whole.

Techniques	Advantage	Shortcomings
Professional measurement	Rich details and reliable accuracy	The high cost, long update cycle, and complicated processes
Images and videos	Wide data coverage and mature image interpretation technology	The data quality is easily affected by weather, light, pedestrians, vehicles, and other factors
High-quality GPS	Can extract refined lane information, complex intersection structure	Professional equipment, high data acquisition costs, long update cycles, and complex processes
FCD	Large amount of data, good real-time capability, wide coverage, low cost	Low data accuracy

Table 3: Comparison between different data collection methods (Li et al., 2018)

More recently, Floating Car Data (FCD) is used increasingly in the mobility domain. FCD represents timestamped speed data. As opposed to traditional traffic collection methods, these data are directly collected by moving "floating" vehicles (Li et al., 2018). It is thus characterized by real-time capability, wide-coverage, large data volume and low cost, solving several issues of the conventional data collection methods (Li et al., 2018).

It can also perform services such as vehicle density, origin-destination matrices, speed and patterns of different vehicle types (Ajmar et al., 2019). It also has a higher sensitivity to traffic events such as traffic jams than other methods. The data collected by such an approach also enables real-time traffic monitoring, time dynamic routing and fleet management (Ajmar et al., 2019; Gühnemann et al., 2004).

The process of FCD is collecting real-time traffic data by locating vehicles through onboard GPS devices in the vehicles or through the mobile phone network. Car location, speed and direction of travel is sent anonymously to a central processing center. This center processes the data to mean travel time or average speed on each road segment.

The reliability of the FCD depends largely on the size of the input data (Pugliese et al., 2009). This is a challenge in the data gathered by onboard GPS devices, as a large sample of equipped vehicles should be used. Usually, taxis or buses are used in this data collection method, as in several countries they are already equipped with GPS devices. However, this data is hard to be taken as a general reference due to the preferential routes of those vehicle types (Pugliese et al., 2009).

Field	Example	Description
ID	221213582622	DI of taxi ,unique
Time	2011-3-22 13:20:15	Beijing Time
Longitude	102.763948	
Latitude	25.091095	
Speed	47	Units: km/h
Orientation	102	Units: degree

Table 4: Description of GPS FCD (Yong-chuan et al., 2011)

In 2007, Google introduced Google Live traffic as an extension of Google Maps. In contrast to the onboard GPS devices, Google uses position data of android smartphones. The data is transmitted to the service provider through the mobile phone connection. Since 2011, these traffic flow data are being used to optimize route calculation in Google navigation, which detects congestion in real-time and helps in avoiding them (Jeske, 2013).

In the Netherlands, a study compares the accuracy and reliability of data collected by a permanently installed dense infrastructural sensor network and Google FCD. They compared the data collection techniques according to similarity, reliability, coverage, sensitivity, and cost. The outcome of the study was that Google FCD could be adequately used for traffic management scenarios analysis, as well as informing and signaling commuters (Haak and Emde, 2018). However, the quality of the traffic state indicator is not sufficient to be used in operational traffic management, such as controlling traffic lights, for example. The coverage of the Google data is sufficient if there is a high enough traffic intensity (more than one vehicle per two minutes). In cases where there is enough traffic intensity, and the analysis of traffic management is of value, the Google FCD coverage is a good match (Haak and Emde, 2018).

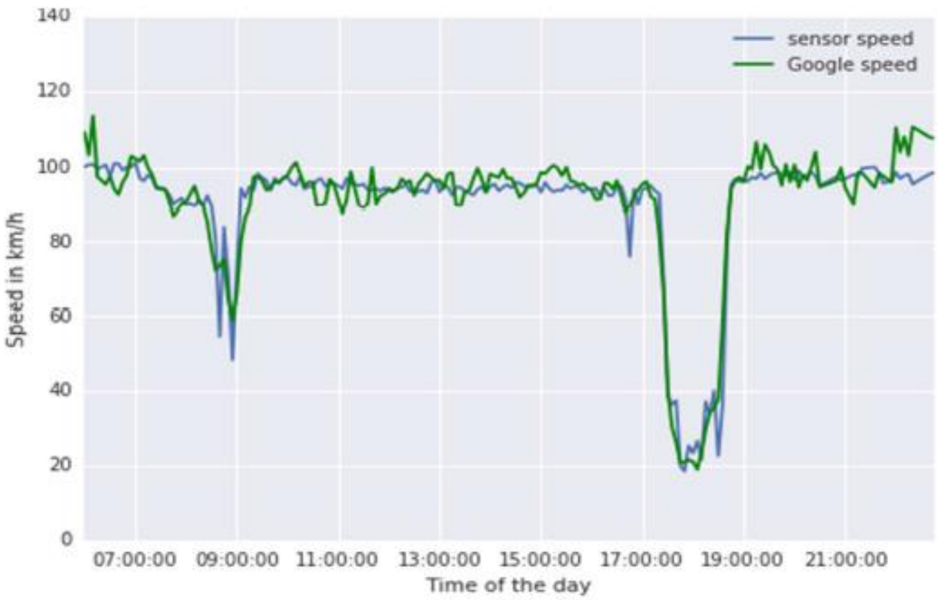


Figure 4: Graph comparing sensor speed measurements with estimated speed based on Google statistics (Haak and Emde, 2018)

Visualization analysis

Through associating FCD positions with a digital map of urban streets, travel behavior analysis is possible using the estimated speed and travel time of vehicles. (He et al., 2014) in (Ajmar et al., 2019).

As mentioned before, FCD based systems have a high sensitivity to detect congestion through the calculated travel times. From the commuter's perspective, the main negative impact of congestion is the loss of time. Thus, measures based on travel time is more easily understood by commuters and traffic managers compared to capacity and queuing-related measures (Gühnemann et al., 2004).

Through the recording of speed value per consecutive road segments, FCD makes it possible to visualize the mean travel speed over the whole network in different moments of the day (Ajmar et al., 2019). This enables inter-temporal comparisons and can be translated into evaluation measures such as travel costs (Gühnemann et al., 2004).

These approaches use a visualization analysis algorithm of traffic congestion that is based on FCD. The process of this method includes several steps: Preprocessing, map matching, travel speed estimation and traffic congestion classification (Zhou et al., 2015). In the preprocessing phase, the data is being cleaned. Data with a speed less than 0 km/h or greater than 120km/h, abnormal driving direction and latitude and longitude out of range (outlier) are being removed (Zhou et al., 2015).

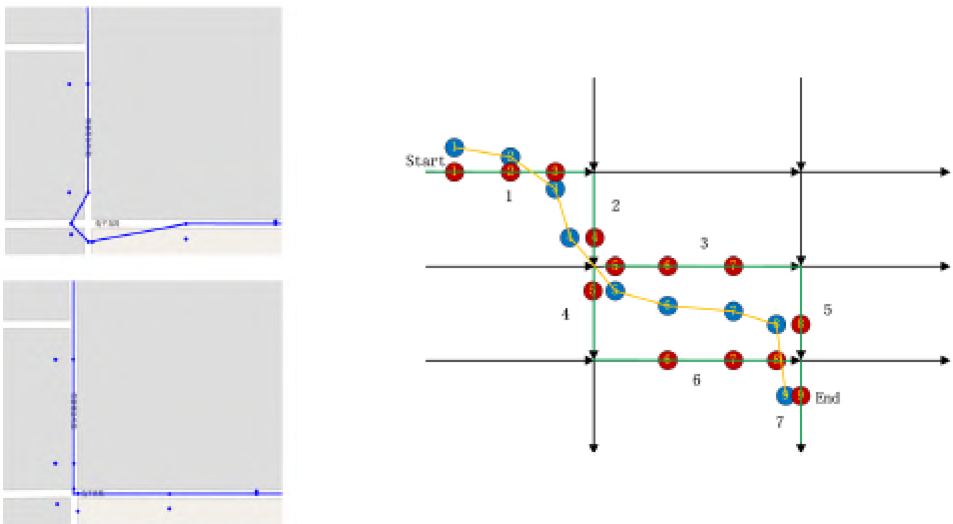


Figure 5: Illustration showing the Map Matching Process (Zhou et al., 2015)

The map matching method is implemented to match the FCD with the road segments rapidly. GPS coordinates have a prevailing error of 3-15m deviation;

thus, the data is being matched to the existing road network and its directions (Zhou et al., 2015).

After that, the traffic speed is estimated for each road segment to present a mean travel speed. According to the travel speed, a traffic congestion classification is applied to present the different traffic states (Zhou et al., 2015). This classification gets color-coded to visually represent each travel speed, enabling the visualization analysis of the traffic congestion (He et al., 2016), as seen in Figure 6.

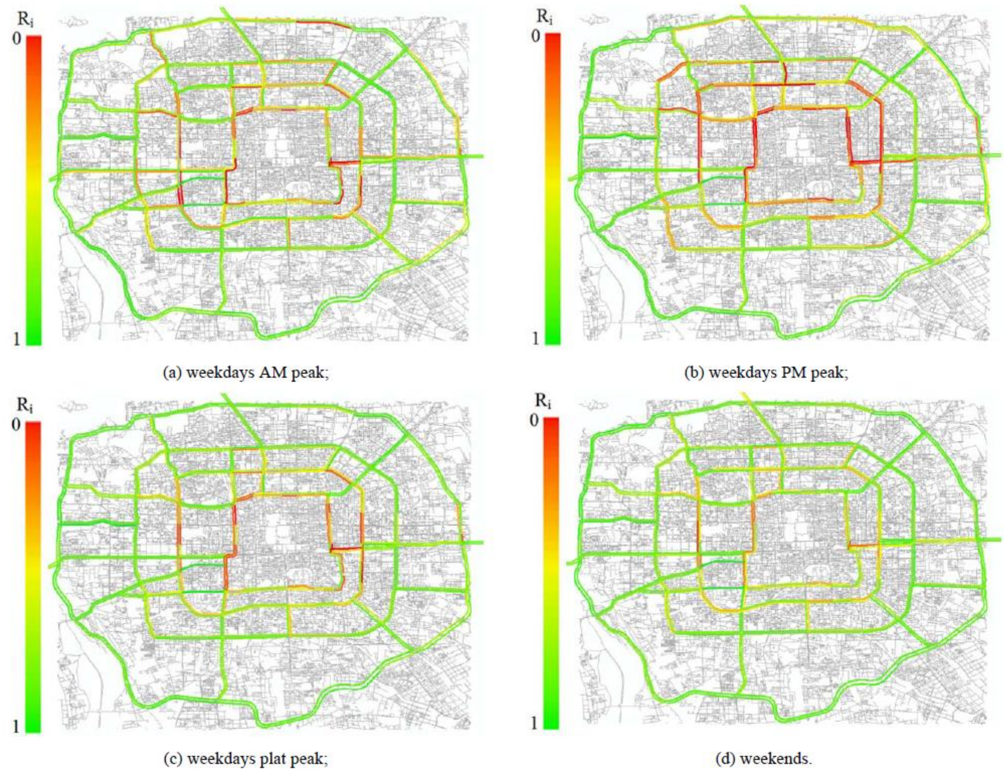


Figure 6: Visualization analysis of congestion through four peak periods (He et al., 2016)

4.2. Urban Travel Behavior on the Microscale

Travel behavior survey

There are at least five different data collection approaches when it comes to travel behavior research (Goulias, 2016). The first and most popular one is the household-based survey and diary activities and trips in a day. This method became a standard for monitoring changes of behavior. Modern travel behavior surveys are designed to be more interactive and using the internet to request data and applying geospatial technologies. The second approach is the panel survey, designed to track the changes along several years using the same sample. The third is the hypothetical questions approach, which asks the respondents about the attribute of choice to study options which are not implemented in real life. The fourth is an interactive experiment approach with the aim to change the behavior of participants by giving them feedback on their past behavior. The last approach is a qualitative approach, using online sources such as social media to collect data on travel, weekly activities, origin and destination patterns etc. (Goulias, 2016). If the data collection should serve the understanding of a specific policy or a certain behavioral change based on a specific issue, smaller subsamples are selected to participate in additional in-depth surveys. This is called a core-satellite design. It can include a detailed one-week diary, in-depth questionnaire etc. (Goulias, 2016).

Data collection method	Data type		
	Actual travel behaviour	Demographic data	Attitudes and appraisals
Interview by phone			
Individual	Yes	Yes	Limited
Household	No	Yes	Limited
Interviewing people in their homes	Yes	Yes	Yes
Questionnaire filled in by the respondents	Yes	Yes	Yes

Table 5: Use of different data collecting methods according to data type (Stangeby, 2000)

In general travel behavior surveys provide data on how and why people travel, the amount of travel and the time spent, the length of trips, the geographical and temporal distribution of trips and how different segments of the population based on demographics have different travel patterns (Dowling and Colman, 1995).

There are two survey approaches to conduct travel behavior surveys, stated preference and revealed preference; some even combine the two (Dowling and Colman, 1995). A stated preference approach gives hypothetical scenarios or situation and asks about the reaction of each participant in this situation, given certain constraints. The revealed preference approach is based on actual responses measurement to alternative existing in reality. Thus, stated preferences are used to explore behavioral changes to a much wider range of options, while revealed preferences measure the specific conditions existing at the time.

In conclusion, travel behavior changes occur when changes happen in the transportation systems and services, such as a change in the road infrastructure. These travel behavior changes can be seen on the macroscale through traffic flow and congestion changes. These changes can be measured through different approaches such as floating car data collection and visualization analysis of the congestion.

On the microscale, these travel behavior changes can be measured through the change in individual travel behavior. Travel behavior can be analyzed through conducting travel behavior surveys which present the different travel patterns of the commuters before and after the change in the concerned transportation system.

Due to the limited local empirical studies in this field, the knowledge gathered from different international literature in this chapter will act as a base for the methodology of this research. Several approaches mentioned in this chapter will be conducted and explained in the methodology chapter.

5. Chapter 5: Introduction to Elevated Transportation Infrastructure in Egypt

This chapter is the first chapter to zoom in to the local context. The chapter presents an overview of the mobility approaches in Egypt. This background knowledge is essential for understanding the local vision, priorities and strategies that affect the mobility and transportation decision-making process in Egypt. The mobility approaches include road infrastructure projects as well as other mobility projects like mass transportation etc.

In the second part of the chapter, the local perception of the elevated transportation infrastructure is presented starting from the local literature supporting and encouraging the construction of such structures, to the ones criticizing and doubting it. Like presented through worldwide literature, the effects of elevated transportation infrastructure on the local context are presented in-depth at the end of this chapter.

5.1. Overview of mobility approaches in Egypt

National Road Project

In 2014, Egypt launched the National Road Project that aims at developing and enhancing the quality of current roads as well as constructing new ones to enhance the mobility in Egypt. This will lead to opening new horizons for investments, the development of the infrastructure and the connection between the different governorates of the country for trade mobility (Extra News, 2019). This new network will lift the traffic pressure within Greater Cairo Region, especially on the Ring Road surrounding the city (Extra News, 2019). In addition to that, the project will enable the building of new urban communities, provision of job opportunities, increase in the national income of the country, as well as the development of the surroundings of the projects (Extra News, 2019).

In the inauguration of several road projects in 2018, President Sisi highlighted the importance of developing the road network in Egypt as well as the whole infrastructure network to achieve the best quality of life for Egyptians (Reda, 2018). The National Road Project is planned to be completed by the end of 2020 and will constitute about 20% of all roads in Egypt (Morsy, 2020).

The project is planned to fulfil the international standards for road networks with a sum of 7000 km of road network and a total cost of 175 billion Egyptian pounds (Al Borsa, 2020). According to the cabinet statement, 5000 km of the new road network is already constructed (Extra News, 2019). In addition to the new network, the existing roads will get developed and their quality enhanced to reach as a total network, affiliated with the Ministry of Transport (MoT), of 30.5 thousand km.

Furthermore, 250 flyovers were built over railways and road intersections with a cost of 30 billion Egyptian pounds, such as Dahshur, Fukah and flyovers of the Suez Desert Road (Extra News, 2019). It also includes the construction of Nile corridors, such as Rod Al-Farag - Adly Mansour and the intersection of the regional road south of Dahshur (Extra News, 2019).

The project is divided into three phases:

Phase 1 includes the construction of 12 new roads with a sum of 3400 km. This includes projects such as the construction of Banha – Alexandria Road, Belbais – Banha – Albagur Road etc. (Al Borsa, 2019). In addition to constructing 1280 km of new roads, ten corridors on the river Nile and 20 bridges and 2500 km of old roads were developed and enhanced, during phase 2. Phase three consists of the construction of 6 roads as well as 20 bridges.

The National Roads Project is implemented by the Ministry of Housing, represented in the Central Agency for Reconstruction, the Ministry of Defense and the Ministry of Transport. Seventeen committees have been formed to supervise the road network projects, in all stages of its implementation. The General Authority for Roads, Bridges and Land Transport has been assigned the technical mandate on the road network of the National Roads Project.

Given that the construction of the projects may result in the expropriation of some lands, President Sisi directed the formation of a committee that includes various stakeholders to limit the properties and the holdings that will be expropriated. It is directed to quickly proceed with compensation of citizens, taking into account their living and economic conditions (Maher, 2019).

In 2014 Egypt was ranked in the world's road quality ranking in the 118th place out of 185 countries. After the start of the National Road Project, Egypt experienced several jumps in the ranking. In 2018 Egypt was in place 75, and in 2019 it reached the 28th place (Morsy, 2020). According to the Chinese Xinhua news agency, the achievement of the leap in the global classification of road quality is due to the adoption of the National Road Project that has so far resulted in the construction of about five thousand kilometres of road network following the international standards (Al Youm Al Sabea, 2018).

Through the national project of roads, the internal and foreign trade will be improved since it will connect domestic networks with international roads as well (Morsy, 2020). Dr. Osama Okeil, Professor of Roads and Traffic at Ain Shams Engineering Faculty, said at a TV interview that the modern road network has economic and traffic goals. It is also in the financial interest of the citizen as it facilitates his access to his work (Okeil, 2020a). He added that there are many developmental roads in the new road network reaching new industrial areas, new agricultural reform areas, as well as tourist and mining areas. He continued that Egypt is living the golden age of roads, through the development and establishment of many road networks, whether national or regional (Okeil, 2020a).

According to a survey by WHO, 62.9% of Egypt's injury-related deaths are a result to traffic accidents. Egypt ranked among countries with the highest mortality rates in the Global Status report on road safety in 178 countries (Magdi, 2015). In 2014 Egypt was in the top 10 annual number of road accident. After the National Road Project, Egypt became number 108 out of 185 countries based on the frequency of road accidents on an annual basis.

Egypt is part of the Road Safety Project 2011-2020, which includes nine other countries in collaboration with the WHO. This project aims to reduce road fatalities around the world by 50% (Magdi, 2015).

In a report issued by CAPMAS on car accidents during the period from 2011-2017, the percentage of change in the number of car accidents during the year 2017 from 2011 decreased by 34% arriving at 11,098 from 16,830. The report also confirmed that the National Road Project contributed to the decrease in these numbers (Heba Hossam, 2018).

The number of accidents from 2017 to 2018 decreased by 41.1%, recording 8480 accidents (Morsy, 2020). In addition to that, the intensity of the accidents decreased. There is a also significant improvement in the mortality rate in road accidents (Reda, 2018).

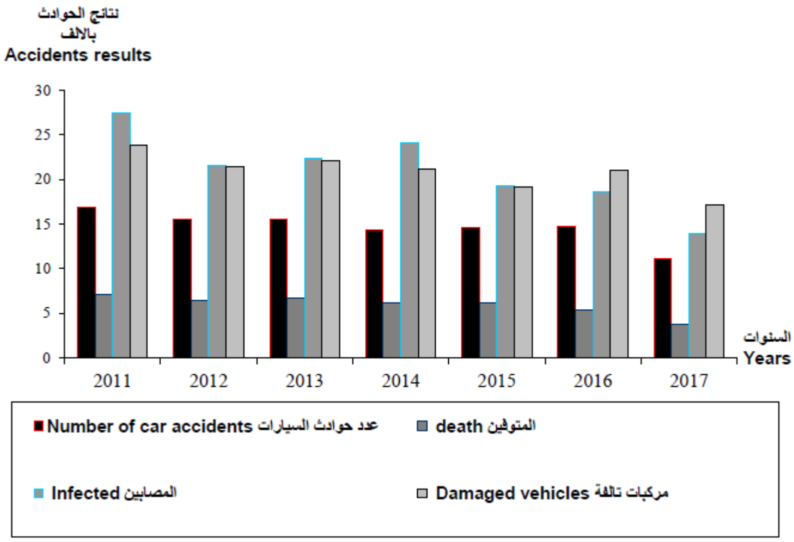


Figure 7: Road accidents between 2011 and 2017 (Heba Hossam, 2018)

The Strategic plan of Cairo 2030

Within the framework of the comprehensive vision for the development of Egypt, known as "Egypt 2030", Cairo Governorate announced that it had completed the development vision plan for the Capital 2030. The goal is to make Cairo more developed in all fields, completely free of problems, and with the ability to avoid any possible obstacles that could occur during the coming years (Masrawy, 2019). The vision of the Capital 2030 is an integral part of Egypt's vision of 2030.

The strategic plan for the Capital 2030 for the development of the road network will operate on three main levels (Cairo Governorate, 2019) in (Cairo 360, 2019; Masrawy, 2019).

The first level is to contribute to the development of the roads that link Cairo with the other governorates. This will be achieved through cooperation between Cairo and the other governorates, whose goal is to develop a road network that links the capital with the governorates such as Giza, Qaliubiya, Suez, Ismailia and Marsa Matrouh (Cairo Governorate, 2019) in (Cairo 360, 2019; Masrawy, 2019)

The second level is the development of the main streets in the governorate. Cairo Governorate operates through allocating annual financial budgets to paving the main streets, and raising their efficiency, to facilitate traffic, prevent traffic jams and create an attractive road network for investment (Cairo Governorate, 2019) in (Cairo 360, 2019; Masrawy, 2019). Among the most important achievements that will be seen during the next five-year plan is the development of a number of vital areas, including the Sayyida Zainab Square, the development of the Al-Fustat area, the Ain Al Haya axis, the development of the Sayyida Nafisa Square, and other major squares and major axes such as the Zakat Foundation and Mustafa Al-Nahhas (Cairo Governorate, 2019) in (Cairo 360, 2019; Masrawy, 2019).

The third level is the pavement and development of internal streets and pathways at the neighborhood level of the governorate (38 neighborhoods are divided into 4 regions, which are North-South-East-West). The governorate plan will include in its third and final level, measures to raise the efficiency of the bridges and tunnels network in the capital and to develop them. Replacement and renovation of 30 bridges and the construction of 12 new bridges for vehicles and pedestrians are in the plan. These developments aim to raise the efficiency and the degree of safety, to reduce travel times, to avoid traffic jams, and to improve the level of service of the infrastructure of the bridges and tunnels network in the capital (Cairo Governorate, 2019) in (Cairo 360, 2019; Masrawy, 2019).

Bridges and Flyovers (Traffic development projects)

Currently, a vast motion of building flyovers is taking place over Egypt and especially Cairo. The main goal of these flyovers is to link Cairo neighborhoods with the New Urban communities, especially the New Administrative Capital, the Banha al-Hur road and the Rod Al-Farag axis with a network of roads. All flyovers are implemented under the supervision of the Engineering Authority of the Armed Forces (Kassab, 2020).

One of the first neighborhood in which the development project started was Heliopolis. The project started with building five flyovers and widening the main streets of the area (Kassab, 2020). More details about the project will be discussed later in the research. Like Heliopolis, several areas are undergoing development projects of this kind. A source in Cairo governorate confirmed that five flyovers will be established to connect Cairo through the east Nasr city neighborhood, to the New Administrative Capital, in addition to two flyovers being established in the Tayaran and Youssef Abbas street (Kassab, 2020). Three more bridges are to be constructed on the streets of Abbas el Akkad, Makram Ebeid and Khader al-Toni. Some of them are already in the construction phase.

Moreover, two flyovers in Al-Matareya district are being constructed, which will enable access from Al-Mahkama square in Heliopolis, until Banha Al-Hur road, and "Tahya Masr" road. Another bridge is planned in Helmeyet Al-Zaitoun neighborhood, which will connect the area with Banha Al-Hur corridor(Kassab, 2020).

According to the Roads and Bridges Survey Bulletin (2015-2016) the total number of bridges reached 2972 bridges, including 1747 bridges belonging to the General Authority for Roads and Bridges, with a rate of 58.8%. Two hundred forty-five bridges belong to the Directorates of Roads and Localities in the governorates by 8.2%, and 49 bridges are belonging to the New Urban Communities Authority by 1.7% (Mansour, 2017). It also included 925 bridges belonging to the National Authority of Egypt Railways, representing 31.1%, and six bridges belonging to the Egyptian Company for Management and Operation of the Underground by 0.2% (Mansour, 2017). The total number of bridges affiliated to the Ministry of Water Resources and Irrigation reached 4481 bridges, including 1640 pedestrian bridges, with a percentage of 36.6%, and 2724 vehicular bridges with a rate of 60.8%, in addition to 117 bridges for other purposes, with a rate of 2.6% (Mansour, 2017).

Mass transit mega projects

With the expansion of Cairo and building the New Administrative Capital, to relieve congestion in Cairo is a major objective. In order to achieve it, a proper transportation network should be constructed, connecting the new cities with Cairo. Thus, besides the road infrastructures, other mass transit projects are being planned.

An agreement with the Chinese bank to provide 1.2-billion-dollar loan to implement a light railway connecting Greater Cairo with the New Administrative Capital is made (Morsy, 2020). This railway will be constructed under the supervision of the Ministry of Transportation by Chinese firms. This project will connect the Greater Cairo Region (GCR) and the new cities with the New Administrative Capital, through reaching the third line of the metro subway in Salam City's Adly Mansour station (Morsy, 2020).

Another rail project is the monorail to be constructed from Cairo Stadium in Nasr City passing through New Cairo till reaching the New Administrative Capital. It will be constructed on an elevated single-rail avoiding any traffic intersections. The main stakeholders of the projects are the Ministry of Housing and the Ministry of Transportation (Morsy, 2020).

Moreover, one of the important rail projects is the extension of the Cairo Metro Subway network. An extension of the existing metro line 3 is currently being implemented. By 2022 the first phase of metro line 4 will be constructed, and by 2030 phase 2 (Transport for Cairo, 2019). These two lines aim to expand the network connecting East of Cairo, with all the new cities, with West of Cairo.

Several other projects are taking place in Cairo as part of the 2030 vision, such as the railway network development project. This project includes supplying new cargo, passenger, and locomotives, as well as constructing new railway lines while upgrading existing ones (ElGioshy, 2017).

Moreover, the construction of a high-speed rail connecting the East and West of Cairo through connecting the New Administrative Capital with 6th of October (Ismail, 2020).

Also, several private transport projects related to connecting the New Administrative Capital to the neighborhoods of Greater Cairo are planned (Ismail, 2020).

5.2. Elevated transportation infrastructure in Egypt

Through studying the international literature on highways and elevated transportation infrastructure, it is obvious how city and urban planners across the world have shifted from being supporters of highways to becoming anti-highways over an average period of 30 years.

In Egypt, the concept of highways, elevated or at-grade, was introduced in the 1970s, when the high commission of Cairo introduced the master plan of Greater Cairo. This master plan was highlighting the transportation infrastructure, presenting projects of highways going through different areas of Cairo. In parallel, the plan of building new satellite cities was in act, which seemed like a good combination, as the highways enable accessibility to those remote cities of Cairo.

Till now the highway oriented urban strategies are the priority, leaving Egypt famous for its multiple elevated highways, with 2972 bridges all over the country (Mansour, 2017). Unfortunately, there is not enough literature discussing the highways in Egypt. Most of the literature discusses the lack of maintenance of highways and bridges, without going through their impacts and effects (Dessouky, 2016).

Reasons for ETI construction

Like many other countries, Egypt is expanding in urbanization. This increase of population and urban growth put a heavy burden on the infrastructure and utilities of the cities, which were not originally built to absorb this amount of population growth. Since the 1970s, the Egyptian government put weight on planning and building new cities to accommodate this population growth.

To expand services and infrastructure to serve this urban expansion, expanding the road network was one of the main priorities. This is where the plan of constructing two radial highways, the Ring Road and the Regional Ring Road, appeared. These roads aimed to improve the traffic situation and free the capital from unnecessary traffic flow, but also to enhance the quality of air, reduce accidents and noise levels within the city (ElHelaly, 2007).

With the focus on road network expansion and development, a considerable percentage of the planned highways are elevated as they are passing over existing infrastructures or urban fabrics (Dessouky, 2016). The first elevated infrastructure, the 6th of October Bridge, was constructed starting 1973. The bridge was planned to be 6 km long linking between Mohandeseen and the Airport, crossing over the old city of Cairo (UN Habitat, 1993) in (Dessouky, 2016).

In general, the road network development focused on a variety of hierarchy roads, using several infrastructure options to solve the intersections and barriers of these roads, such as elevated highways, flyovers and underpasses. According to Huzayyin and Salem (2013), Cairo achieved a lot in mitigating traffic problems. One of the main reasons are the elevated roads (Huzayyin and Saleh, 2013).

Criticism of ETI construction

Agns Deboulet (2010) explains that Middle Eastern cities use urban highways as a tool to bring prestige and brand modernity. In cities like Cairo, these infrastructures alter the environmental and social setting of the city. According to her, Middle Eastern governments use the construction of urban highways to substitute urban policies that cannot cope with urban growth (Deboulet, 2010). While these road infrastructures helped in reducing the traffic within cities, they are also reflecting the intention of escaping the old districts of Cairo. In the past 20 years, elevated road infrastructures are constructed to pass over the crowded districts of old Cairo.

Based on S. and K. Cullinane (1995), a proper number of aesthetically pleasing architecture got destroyed by the road infrastructures, such as road, highways, flyovers and tunnels. As an example, they mentioned Tahrir and Ramses square, which the chaos of concrete destroyed the landmarks and built environment. In their opinion, the whole Cairene population is suffering from the unpleasant built environment, characterized by flyovers, which serve a small percentage of the population (Cullinane and Cullinane, 1995) in (Dessouky, 2016).

Similar to the arguments made on the international level, local practisioners and planners started introducing the idea of induced traffic based on the increase of highways to the local context.

Moreover, the induced traffic concept started to get introduced in the local context of building highways and flyovers. Widening the streets is seen as a very short term solution, due to its effect of encouraging people to use private cars more and thus create more traffic (Hegazy, 2020). In a brief series discussing sustainable mobility, Dr. Ahmed El-Dorghamy (2020), an expert on Energy and Environment, explained how the expansion of roads are only postponing the traffic problem. He discussed the concept of induced traffic, how it was introduced in 1994 and how since then cities around the world are moving towards the concept of sustainable cities (El-Dorghamy, 2020a a). These cities try to achieve this concept by removing highways and introducing alternative mobility options such as enhanced public transport and active travel infrastructure. Cities which managed to do this experienced an increase in investments and property value (El-Dorghamy, 2020a a).

In Cairo, neighborhoods like Downtown experienced a reduction of road space for the benefit of expanding the sidewalk by around 50cm in Talaat Harb Street (El-Dorghamy, 2020b b). Other areas like Al Alfy, Shawarby, Borsa and Al Cornich underwent similar pedestrianization projects. These project had benefits on the pedestrian life of the city, while not negatively affecting the traffic in any way (El-Dorghamy, 2020b b), unlike many people might expect.

The SubMonitor (2020) described the situation to be a “catch-22 situation”. If public transportation remains underfunded, people are more prone to use private cars, which then increases the traffic. This is then solved temporarily by street widening, highway and flyover construction. After providing short term relief, the induced demand appears, and the congestion comes back again. This affects the private car users but also the underdeveloped public transportation services, which then pushes more people to use private cars, and the cycle keeps on repeating (The SUbMonitor, 2020). In his opinion, the problem should be solved from the source in order to have a long term solution (The SUbMonitor, 2020).

According to the president of the General Authority for Roads, Bridges and Land Transport, Egypt is now left with around 700 bridges that exceeded their lifespan and are at risk (ElSharnoubi, 2014). Due to the lack of maintenance plans, these elevated infrastructures are deteriorating. The reason for that is that decision-makers usually prefer to build new bridges to be added to their list of achievements rather than maintain the existing structures (Dessouky, 2016). Another reason behind the deterioration of the bridges and the lack of maintenance is the overlapping of responsibilities between the different Egyptian authorities, which make the decision-making process more complicated.

Effects of ETI on the urban environment in Cairo

Based on local literature, the effects of the flyovers or generally any bridge on the urban environment can be categorized into several parts, such as perceptual, spatial, functional, social, environmental, and economical (ElHelaly, 2007). All these categories belong to different urban environment dimensions.

Perceptual aspects (identity & aesthetics)

One of the obvious effects of the bridges on the urban environment is the change in the cultural identity of the area the structure is built in. This aspect is one of the most expressed criticisms of such structures in areas with a valuable cultural identity like Heliopolis. Some people believe that the preserving of this identity should be prioritized over the flow of transportation (Dessouky, 2016).

These concrete masses are barriers hiding architectural features of historically significant buildings and result in visual pollution. They can also result in people losing the sense of place of the area through the change of places carrying memories and events meaningful to them. Because most of the ETIs look the same regardless of the area they are built in; this creates monotonous environments across neighborhoods (ElHelaly, 2007).

Spatial aspects (urban fabric, land use)

Constructing elevated transportation infrastructures in the urban areas, sometimes result in a change of the land use of the area. People start leaving the area due to other negative impacts such as pollution for example, and instead, commercial and administrative uses usually replace them. This phenomenon happens more in the buildings directly facing the ETIs, and thus often these streets shift from residential to commercial streets (Dessouky, 2016). Moreover, the residents moving out of the area could lead to urban fabric changes. In some old neighborhoods where the buildings are mainly low dense or villas, the common result of the people moving out is that the villas get torn down and multi-story buildings replace them.

Another effect on the urban fabric is the segregation between the areas of the neighborhood through the massive structures. This can also lead to losing orientation of the neighborhood and for it to start to feel fragmented (ElHelaly, 2007). These structures can also lead to urban degeneration to areas around them, similar to what happened in the areas surrounding the Ring Road (The SUbMonitor, 2020).

While in most cases the ETIs contribute in creating undeveloped, underused or deteriorated spaces around and especially beneath them (ElHelaly, 2007), in some cases the impact of those structures on the creation of spaces is rather positive. The traffic being lifted to the ETIs, some areas in Cairo, like Saft Al Laban, for example, experienced the appearance of new activities in the newly created spaces freed from cars (Dessouky, 2016). In addition to that, the area under the bridges acted as a free space for pedestrians in that area (Dessouky, 2016).

Functional aspects (accessibility)

In many flyover cases, the width of the at grade street gets decreased. This leads to more traffic underneath the flyover, causing noise, pollution, and lack of parking spaces. This situation also influences several users of the neighborhood (Dessouky, 2016). For residents, this decreases the access to their building located on the street of the flyover either by walking or by car due to the lack of parking. In commercial areas, these effects repel shoppers from coming to this street, due to the traffic and lack of parking. For pedestrians, the through movement becomes very difficult, especially at the ramp area of the flyovers; hence the pedestrian activity decreases in this street (ElHelaly, 2007).

Social aspects (safety, privacy, engagement with spaces)

According to people in neighborhoods that have been affected by an ETI, these structures influence the social fabric of the area (Dessouky, 2016). Some areas were enclosed and had a certain community, however, with the increase of accessibility to the area through the ETIs, more people started visiting the area which changed the social fabric of the neighborhood (Dessouky, 2016).

Due to the heavy structures cutting through the urban fabric, social segregation and fragmentation occur, which leads to the loss of community (ElHelaly, 2007).

Another social aspect that is heavily affected by the ETI is the safety of the people. On the one hand, accidents happen due to the speed of cars moving through the flyovers and streets (The SUbMonitor, 2020). One the other hand, security incidents occur due to the dark, unmonitored spaces under the elevated structures (ElHelaly, 2007). In some cases, even accidents happening on the flyover can affect the street at-grade if anything falls from them (Dessouky, 2016).

For several people, another affected social aspect is the lack of privacy resulted from the flyovers. Buildings directly located on the flyovers have a problem in privacy as the car movement got elevated to their apartment levels. As a result, several architectural changes happen to the facades to attain proper privacy to the residents (ElHelaly, 2007). In addition to that the constant noise due to the traffic on the flyovers and on the at grade streets affects the privacy of the residents.

Overpasses affect the pedestrian viability due to the decrease of accessibility for pedestrians. This leads to the loss of street life, thus the streets becoming no longer part of the social space (ElHelaly, 2007).

Environmental aspects (microclimate, green cover, pollution)

Environmental impacts such as pollution and noise are common in areas with overpasses. The emissions of the increased traffic flow on the flyovers as well as the potential congestion in the at-grade narrowed streets cause air pollution (ElHelaly, 2007).

In addition to that, usually, to construct a flyover, the street needs to be widened, and thus the greenspaces at the median or on the sides are removed. This loss of green spaces contributes to decreased air quality, climate change and loss of habitat (ElHelaly, 2007).

Economic aspects (viability, land value)

Economically the flyovers have controversial effects depending on the area (Dessouky, 2016). In some areas, the lifting of traffic to the flyovers clears the space underneath for shoppers, commercial activities, as well as the logistical loading on and off products for the shops. In other areas, the flyovers resulted in narrowing the at-grade streets, decreasing the parking sports and creating traffic, which acts as a repellant for shoppers to choose this street. In addition to that, commercial streets that depend on passersby usually get affected the most as the traffic flow gets elevated from the surface (Dessouky, 2016).

Like the effects on the commercial aspect, the land and property value vary depending on the area. Areas like Saft El Laban, for example, experienced an increase in land value when an ETI got constructed there (Dessouky, 2016). Other areas like Zamalek, faced a decrease in property values of the building directly facing the 15th of May bridge.

Conclusion

From the data gathered from literature, news and journals about the general mobility approach in Egypt, it is evident that a lot of effort is currently put in the transportation sector. Megaprojects like the National Road Project and strategies like the Capital 2030 Strategy are going towards intense development of the road infrastructure across Egypt. Accompanied by this development, is the vast motion of building flyovers, especially in the cities of Cairo, such as Heliopolis. However, other projects are being implemented in the mass transit sector as well, connecting several cities within Cairo, especially the new cities to inner Cairo.

When discussing the evolution of the road infrastructure in the local literature, it is obvious that there is limited literature available debating this matter. While a shift of perspective is not clear in the local context like in the international one, several for and against opinions are present simultaneously. For some, the road infrastructure development is a sign of modernity and prestige, and for some, it is a way to destroy the city, the environment and the social setting of the area.

Looking into local resources that study the effects of the elevated transportation infrastructures on the urban environment, limited literature is available. Nonetheless, the last part of this chapter was dedicated to discussing these impacts. The effects are related to all urban environment dimensions and include perceptual aspects such as identity and aesthetics, spatial aspects, such as the urban fabric and land use, as well as functional aspects, like accessibility. Moreover, social aspects such as safety, privacy and environmental and economic aspects were discussed.

6. Chapter 6: Case study – Heliopolis

After having an overview of the topic on the national and regional scale of Egypt and Cairo, this chapter zooms in on the scale of the case study. The chapter is divided into three main sections, one going through the background and history of the construction and establishment of Heliopolis, reaching the current state of the district. The second one discusses the different mobility approaches in Heliopolis from the beginning until the present time. The last part is presenting the traffic development project newly introduced in Heliopolis with all its details.

6.1. Introduction about Heliopolis district

Cairo witnessed an increase in population at the beginning of the 20th century leading to two transformations in the city. Existing districts got densified as well as new districts were developed. At that time the new districts were Giza, Garden City and Rhoda, in addition to two suburbs, Heliopolis and Maadi.

The river Nile lies to the west of Cairo, and Mukkatam Hills to the east, the expansion of Cairo was limited in those directions. The area on which

Heliopolis was built, was around 12 km into the desert, as a plan to redevelop the capital outside the old city limits (Nowier, 2014).

Heliopolis was founded by the visionary Belgian Edward Empain, as an expression of a personal dream not as an outcome of a planned project. The preliminary idea was to create two oases in the desert (Herzog et al., 2010). One being the luxurious residential part and the other the service area for the first one. In 1905, he was granted the property area of 25 km2 in the desert of Abbasiya by the Egyptian Government. Less than one year later, Cairo Electric Railways and Heliopolis Oases Company were established. The aim was to establish a city in the desert outside of the fertile zones of Cairo while being linked to it by tramline. Despite this aim, the company did not build the entire city. Its intention was to sell plots of lands that are fully serviced after completing the infrastructure and facilities of the city. Between 1907 and 1916, however, the company started constructing buildings to sell the developments (Nowier, 2014). Heliopolis was built to be autonomous and self-sufficient in infrastructure, such as water and electricity, totally independent from Cairo while being linked through a tramline (Nowier, 2014).

The city was built to be a garden satellite by foreign architects, Belgian, French and British, however in a way that conforms with the culture of the country. They included a lot of details and ornaments following the Arab traditions while keeping the European driven architecture in the plans. “Heliopolis was held up as an example of a ‘happy marriage’ between the West and the East” Hassan Fathi (Kadi, 2005).

Today

Currently, Heliopolis consists of two main parts, the old city (Korba), which was built by Baron Empain and the new urbanization that came after it (Nowier, 2014).

Heliopolis has six districts: Al-Bustan, Almazah, Al-Muntazah, Al-Nozha, Al-Matar (the Airport) and Al-Sheraton. The first three were established in the initial development and the last two were planned during the 60-ies, but the urbanization began only in the late 80-ies (Abdelaziz Mahmoud, 2007) in (Nowier, 2014).

Today, associated with Heliopolis are two main administrative districts, Heliopolis Districts, which combines Al-Bustan, Almazah and Al-Muntazah and another district, called Al Nozha district, combining Al-Nozha, Al-Matar (and Al-Sheraton. Heliopolis district has a total area of 9.38 km2, 2.6 km2 urbanized with around 141 903 residents, resulting in a density of around 15000 capita per km2 (Cairo Governorate, 2016; City Population, 2018). As for Al Nozha district, the area is 67.6 km2 with a population of 238 550 residents (City Population, 2018).

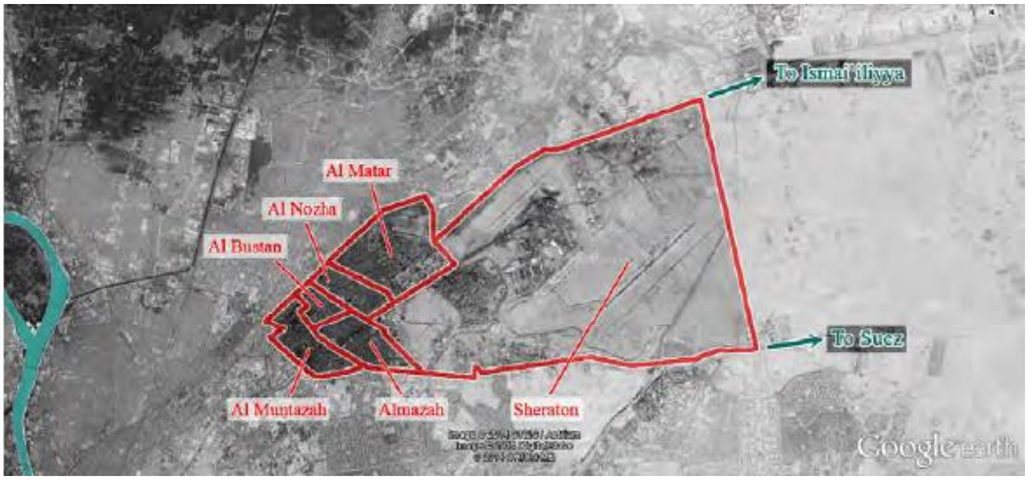


Figure 8: Map showing the six districts of Heliopolis. (adopted from Mahmoud, 2007 by Noweir, 2014)

6.2. Mobility approaches in Heliopolis across time

When the Baron bought the area of Heliopolis, it lacked all the facilities, including transportation. Baron wanted to link his new suburb to Cairo, to attract people to it; thus, he considered building a tram.

The Belgian engineer, "Andrei Bracello", was tasked with establishing the tramline. This tram was the core of the development of the new city in the desert, making Heliopolis a successful Transit Oriented Development (TOD), before even inventing this term (The SUbMonitor, 2020). It operated starting 1909 with its first line connecting Cairo to Heliopolis, followed by a second line in 1911(Wakil et al., 2016).

Figure 9: First pictures of the Tramway of Heliopolis (City in a City, 2010)

In the 50-ies the network extended through new carriages provided by Toshiba until it reached four tramlines as seen in Figure 10 . Ever since, the tramline and its carriages remained the same, with the quality of service decreasing bit by bit (Herzog et al., 2010). However, it remained one of the distinctive features of the neighborhood until in 2014 the former governor of Cairo, Dr. Jalal Saeed decided to remove the tramline, part of it was removed due to security reasons (Sharkawi, 2018). The rest was removed because of its deterioration and low ridership rates resulting from its bad condition due to the lack of maintenance fund (Okeil, 2020b). The idea was to use this space to expand the main roads of Heliopolis. This decision was a trigger to the anger of a large segment of Heliopolis residents.

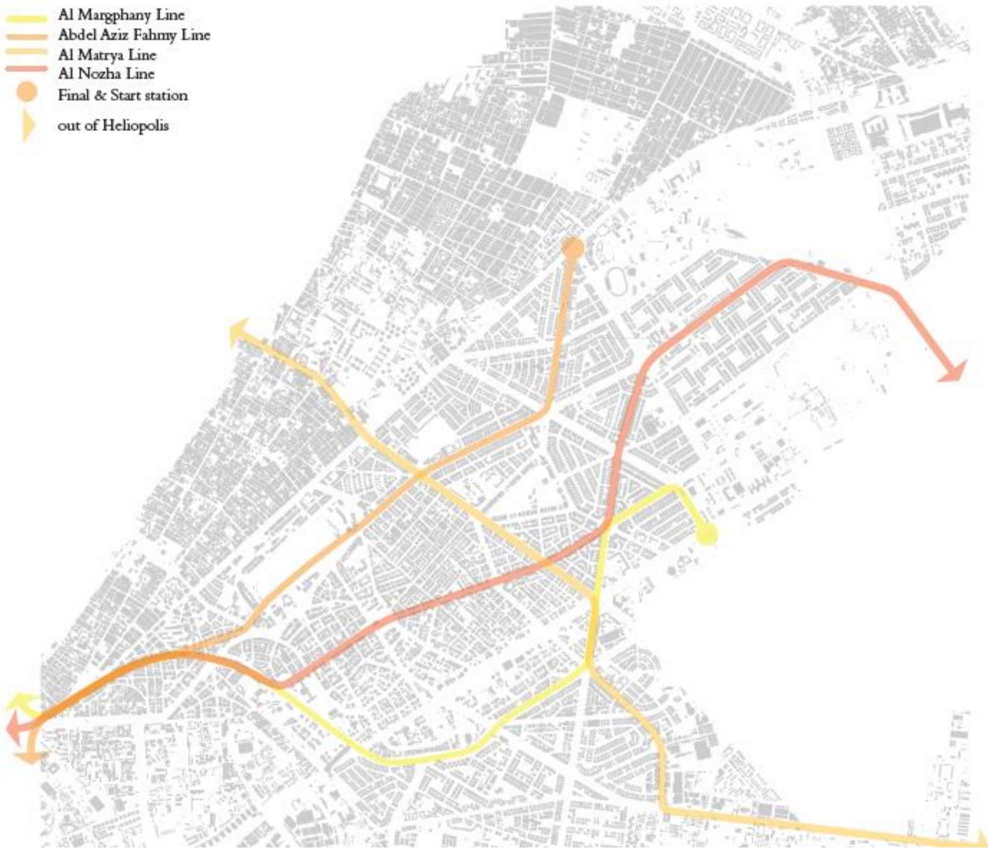


Figure 10: Heliopolis Tramway Network

Since the beginning of Heliopolis, the tram was the most dominant mean of transport. There were some cars and carts too, however not competing with the tram. In the 60-ies the road network expanded, and the public buses started to appear for the first time (Wakil et al., 2016). With the emphasis on the trade and the increased movement to the city in the 70-ies, the density of the city and the mobility by using private cars increased. In 2013 the first metro station opened in Heliopolis, introducing a new mobility mode to the city (Wakil et al., 2016).

Currently, due to the higher social classes living in Heliopolis, the car dominates the streets of the district. With the limited frequency of the buses and the worn-out then removed tramline, the cars and taxis became the most reliable option for the residents (Herzog et al., 2010). Recently new metro stations opened in the area, increasing the reliability of the metro network for the district (Herzog et al., 2010).

Nevertheless, car dominance leads to traffic being a big issue in Heliopolis. The main streets with an average of 30 – 40 m width are oversaturated and jammed for several periods a day, leading up to 3-hour traffic jams (Herzog et al., 2010).

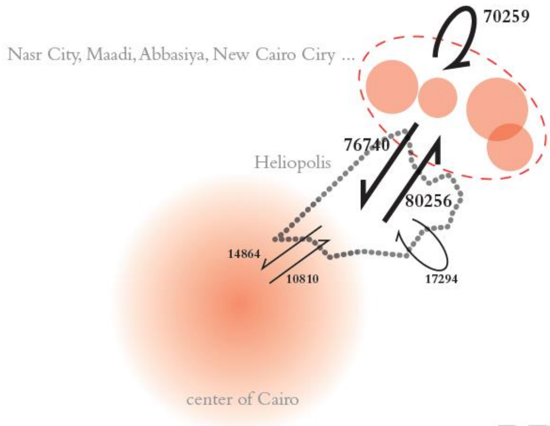


Figure 11: Total routes between Heliopolis, Cairo, and other districts for one day (City in a City, 2010)

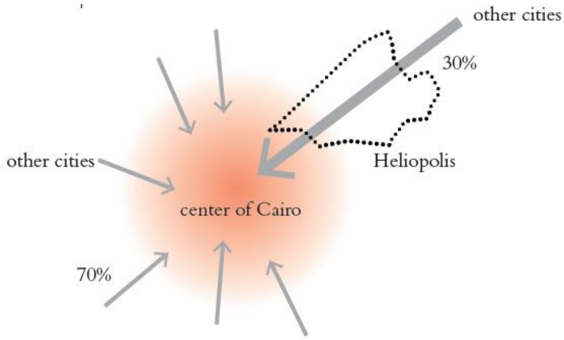


Figure 12: Heliopolis as the Gate of Cairo (City in a City, 2010)

Traffic analysis shows that the main traffic generator is transit trips. Only 5.5% of the traffic goes from Heliopolis to the city center, and 4% goes from the city center to Heliopolis. However, 30% of the traffic pass by Heliopolis to reach the city center or the new desert cities, in addition to the people coming and going to the airport (Herzog et al., 2010). This analysis supports the same argument of Dr. Ossama Okeil of Heliopolis being the link between the west and east of Cairo and the entrance to the new cities (Okeil, 2020c).

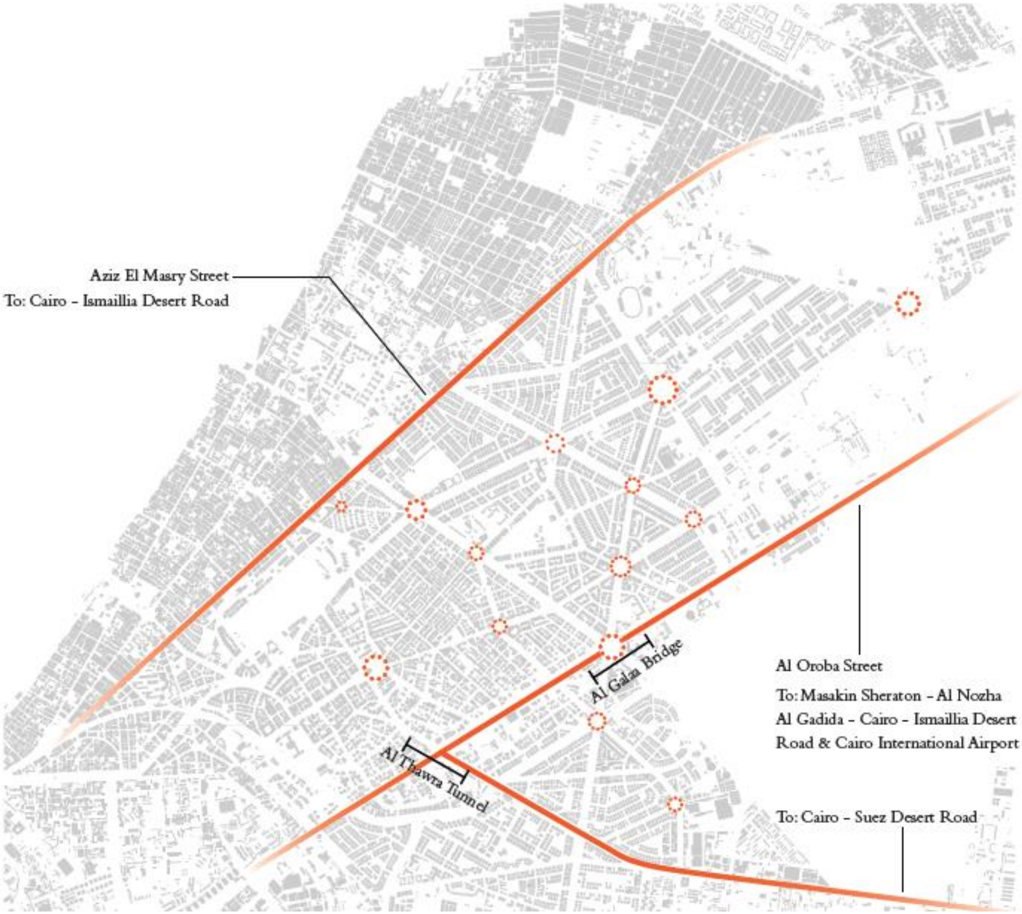


Figure 13: Traffic situation in Heliopolis solved by Tunnel and Flyover (City in a City, 2010)

Figure 13 from the book “Heliopolis - City in a City” (2010) shows the most jammed streets back then. As a solution, two crossings were replaced through a tunnel and a flyover. The motion of building tunnels and flyovers to solve the traffic problem started in 2003 (Wakil et al., 2016). Ever since, traffic problems occurring more frequently in several areas of the district, are being solved with more and more flyovers.

Figure 14: Greenery Types in Heliopolis

To be able to implement such infrastructures, the streets need to be widened, which is only possible through removing the green medians in the middle of the main streets, as shown in Figure 14. The greenery in the streets was one of the elements on which the city was planned. Now due to the new traffic development strategy, most of them are removed to free the way for the broader streets and new flyovers.

6.3. Introduction to the traffic development project in Heliopolis

In September 2019, a traffic development project started in Heliopolis. The project aims to facilitate traffic inside Heliopolis neighborhood and link it to the main axes that extend to the neighboring urban communities and new cities, as well as to inner Cairo. Heliopolis was the first district in Cairo to undergo such development due to its unique location acting as a link and entrance between the east and west of Cairo. Based on the anticipated increase of traffic demand potentially generated by the New Urban Communities, especially the New Captial, Heliopolis became a priority in accommodating the expected growth of capacity before resulting in more critical traffic issues (Okeil, 2020b).

The Suez Road turned from being a regional road connecting Cairo to Al Suez to a road acting as a main spine linking the New Urban Communities on both of its sides, as well as the New Administrative Capital with one another and with the rest of Cairo (The SUbMonitor, 2020). To accommodate the travel demand generated by those cities, the Suez Road was expanded several times. This expansion led to the creation of a bottleneck situation at the entrance of the Suez Road in Heliopolis (The SUbMonitor, 2020). This increased the urgency of introducing such a traffic development project in Heliopolis.

President El-Sisi directed the completion of these projects as fast as possible, giving a strict timeframe to alleviate the suffering of the citizens and residents of Heliopolis neighborhood (Egypt's Projects Map, 2019). The projects should be built according to the highest quality standards, considering the architectural character of the neighborhood.

Several interviews were conducted with Dr. Ossama Okeil, a Professor of Transportation and Roads at Faculty of Engineering at Ain Shams University and the planner and engineer of the traffic development project of Heliopolis, discussing the details of the project.

During an interview, Dr. Ossama released the date of the project completion to be June 2020 (Okeil, 2020c), explaining the five phases of the project (Okeil, 2020c):

- Phase 1 includes the construction of five flyovers near Almaza area
- Phase 2 includes the development of the connection from St. Fatima area to Triumph area reaching to North Heliopolis
- Phase 3 will develop a new entrance to Heliopolis from Suez Road to Al Saaqah Road leading to Autostrad Extension corridor and Sheraton
- Phase 4 includes the construction of a new corridor reaching from Roxy to Ramsees Square and to Al Dokki area, this will enable people to reach Ramsees Square from Heliopolis in less than 5 mins
- Phase 5 includes the construction of a corridor linking Heliopolis to the Ring Road and Shobra Banha Al Hur Road to reach Rod Al Farag Corridor eventually

The project includes several flyovers like Al-Merghani and Al Sabaa Omarat Flyovers, the integrated development of Roxy Square and the squares of the districts of Safir, Haroun and Al Tagneed, as well as new corridors in the streets of Al Nozha, Abu Bakr and Khalifa Al-Mamoun. Moreover, new traffic management regulations in terms of changing some of the street directions to become one-way streets, such as Thawra and Omar Ibn Al Khatab street (Egypt's Projects Map, 2019). As a result of building these elevated infrastructures and widening the street, the main corridors in Heliopolis became urban freeways. Thus the project includes several pedestrian bridges as well as pedestrian traffic signals for at grade pedestrian crossings to enable safe active travel mobility (Okeil, 2020c).

According to Okeil (2020), Heliopolis was isolated by the surrounding neighborhoods, such as Al Zatun area, which are blocking Heliopolis from the west. For Heliopolis residents to take Shobra Banha Al Hur Corridor, they needed to take the Ring Road for 42 km although they are 8 km away from it. This is a result of the lack of direct linkage and congestion (Okeil, 2020c). Now the new connection will take them 8 mins to arrive at the same point (Okeil, 2020b).

As mentioned before, Heliopolis is the entrance of east of Cairo, attracting a lot of traffic going through the neighborhood. With the new project the travelers will be directed through the Ring Road, not needing to enter Heliopolis, to go from east to west of Cairo or vice versa (Okeil, 2020c).

Professor Ossama (2020) highlighted that this project is to serve east of Cairo as a whole, including New Cairo, Obour, Madinaty, New Heliopolis and Shorouk, not only to be a link and entrance for the New Capital. Thus, this project aims to think ahead and anticipate the traffic capacity that will be generated in the future by the increase in urbanization in those cities and accommodate it (Okeil, 2020b).

Despite the huge criticism from the citizens towards this project, Okeil highlights that it is normal to feel lost and confused at the beginning and called it "Post Opening Chaos". In his opinion, the majority of the citizens are beneficiaries of this project, and only 1% of the people might be negatively affected. Compared to the number of benefits this project creates, these negative effects are seen as "side effects" that are worth having (Okeil, 2020b). He also mentioned that the positive effects of the projects are starting to appear already. The air quality measured before and after the project improved due to the reduction of congestion (Okeil, 2020c). Based on Cairns et al. in the report of "Disappearing Traffic? The Story so far" the air quality improvement due to new road infrastructure happens because of the elimination of the stop-and-go-driving caused by congestion. However, this claim has been challenged, as the improved air quality benefit of new road capacity in the short term will be counteracted by the increased travel demand on the longer-term (Cairns et al., 2002).

Another effect mentioned by Okeil was the increase in property values in the area. Although there is no proof of this happening currently, some real estate development platforms started mentioning the project and its positive effect on traffic in the advantages of living in Heliopolis (AqarMap, 2020).

Besides creating more links and connections between several areas within Cairo, reducing congestion, and improving the air quality, the project aims to tackle the parking issue in Heliopolis as well a prepare the city for providing improved mass transit services. One of the aims of this project is to prepare the roads for at-grade mass transportation providing high-quality services to encourage people to leave their car and shift to public transit (Okeil, 2020b).

The project's estimated cost is more than 7 billion EGP, which includes a new network of water pipes for Heliopolis, the flyovers, the street widening, traffic lights, pedestrian bridges and transferring underground facilities (Okeil, 2020c).

The main stakeholders responsible for the project are the Cairo Governorate and the Engineering Authority of the Armed Forces. Other stakeholders such as the Parliament, Civil Society Associations (Misr El Jadida Association, Heliopolis Company for Housing and Development) and the cabinet, are involved in the project as well.

When asked about the process of planning and choosing the location and type of intervention, Okeil responded with the steps used to develop this project. First, the network and traffic flow are analyzed to identify the areas influenced and affected and the areas of high demand and attraction. Then a traffic model gets developed to enable the development of simulations. Only after simulating all possibilities and examining their effects, solutions are being proposed (Okeil, 2020c). Some of the preliminary analysis highlighting the problems and the proposed solutions for the area are being discussed in the following section.

Study area analysis

As mentioned by Dr. Ossama Okeil, in-depth analysis, modelling and simulation were conducted to arrive at the optimum solution for the current traffic problem in Heliopolis. In the following part, a presentation of the outcome of study area analysis is shown in one of Dr. Ossama Okeil's interviews (Okeil, 2020b), as well as civil conferences conducted by him and other stakeholders involved in the project implementation process (Okeil and Fouad, 2020). The date of conducting this analysis as well as the methods used to collect the data are unknown.

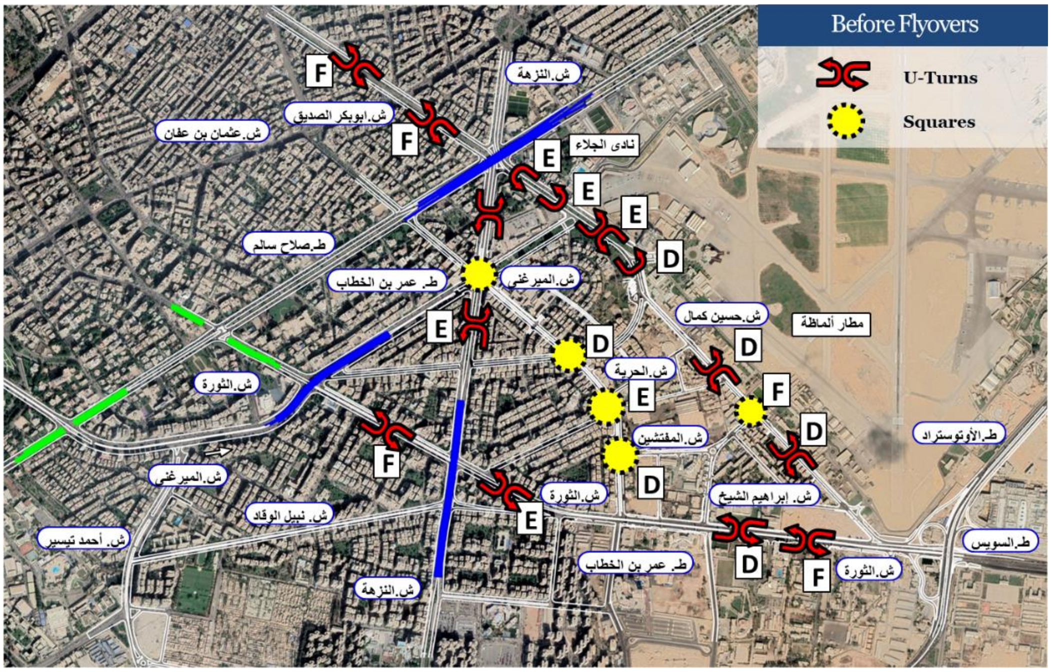


Figure 15: Heliopolis before the Traffic Development Project (Civil Conference published by Heliopolis Heratige Initiative, 2020)

In the previous state of Heliopolis, the road network was consisting of streets, intersections, squares, and a lot of U-turns, sometimes reaching eight U-turns in one street. Also, there were three flyovers and two tunnels previously built to eliminate congestion at those intersections, the first two, Al Nozha and Al Marghany, were constructed in 2003 (Wakil et al., 2016).

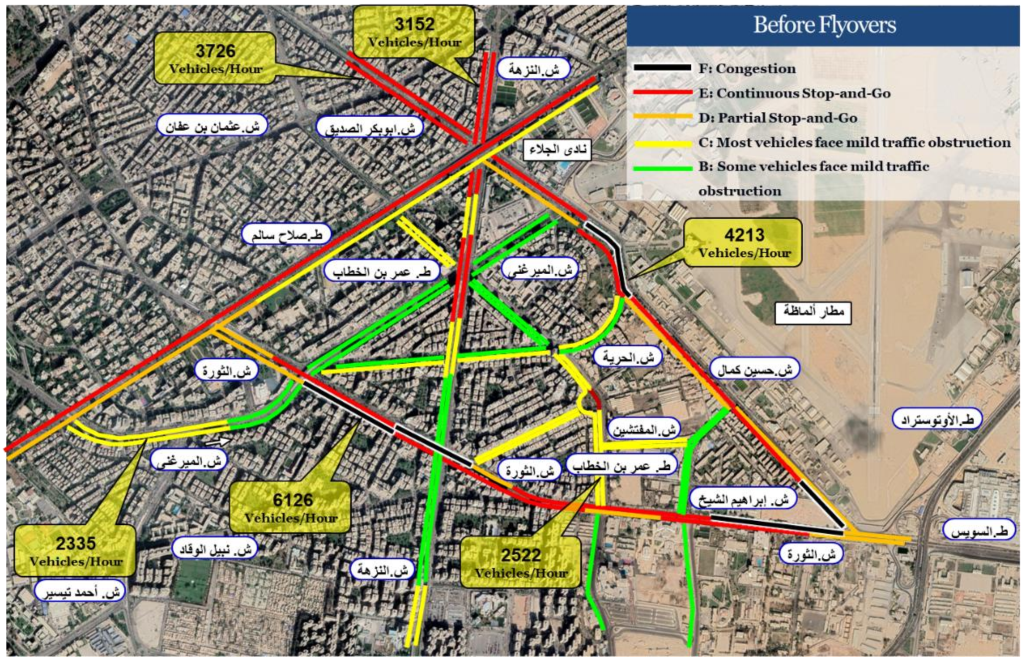


Figure 16: Congestion in Heliopolis before Traffic Development Project (Civil Conference published by Heliopolis Heratige Initiative, 2020)

According to the traffic visualization analysis above, most of the main streets of Heliopolis are congested. Based on this analysis, there are no freeways within Heliopolis, the capacity of the major road network and intersections is low, and there is a problem with parking areas in the district, increasing the illegal parking spots (Okeil, 2020b).

The proposed solution to the challenges mentioned above was to convert main streets that accommodate traffic flows from and to Heliopolis into freeways, increasing their capacity and travel time through street widening and removal of any interruptions such as intersections. This was done by constructing five flyovers to eliminate congestion caused by intersections and squares, as well as eliminating U-turns on the main axes of Heliopolis and introducing one-way streets. Moreover, spaces for parking should be provided.

Main streets like Al-Thawra Street, Hussein Kamal Street, and part of Al-Hurriya and Omar Bin Al-Khattab Streets were expanded as well as service roads on both of their sides were provided. Al-Merghani and Abu Bakr streets were widened through removing the tramlines.

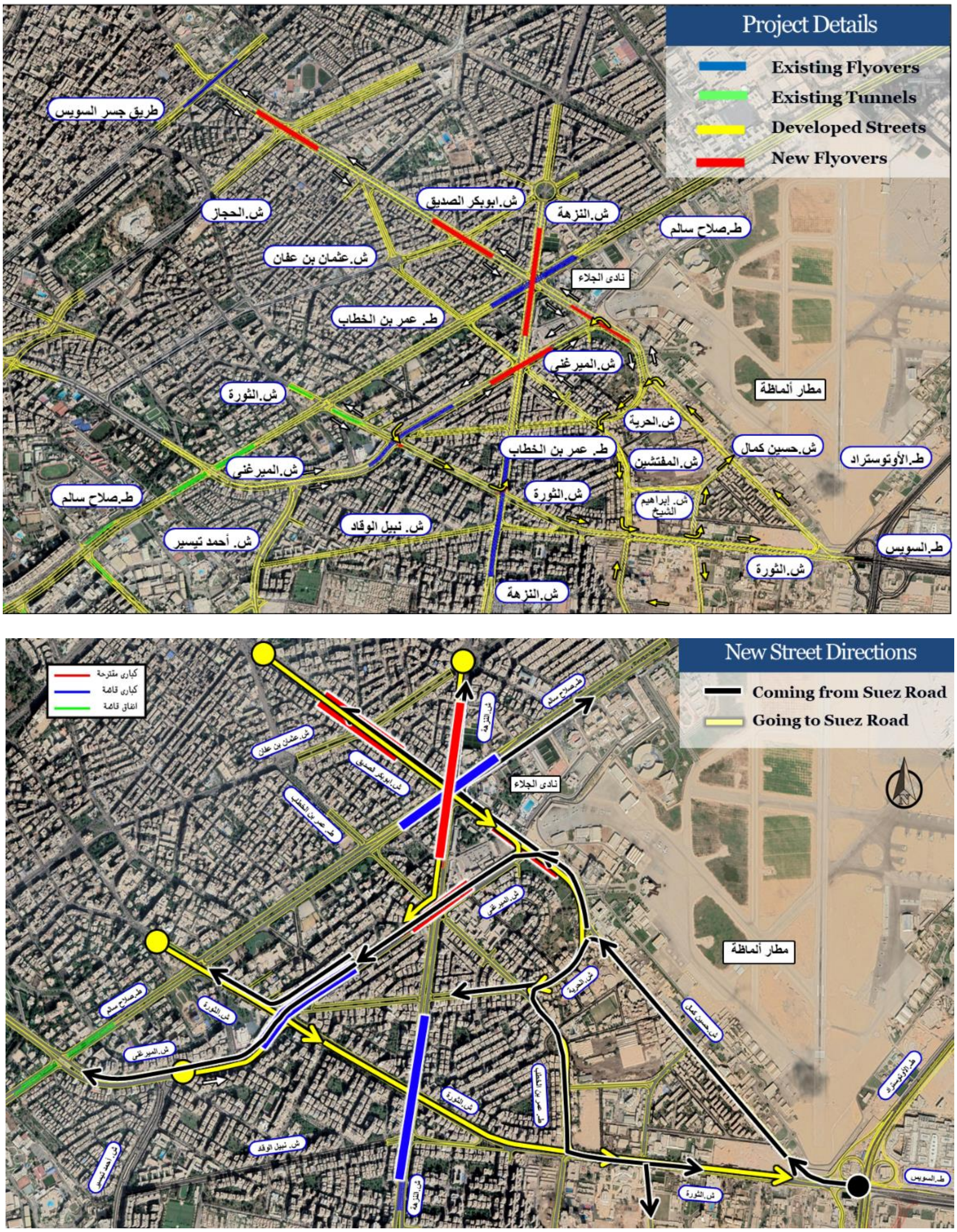


Figure 17: Maps showing the Heliopolis Traffic Development Project interventions (Civil Conference published by Heliopolis Heratige Initiative, 2020)

Conclusion

Heliopolis is a city that became a district by time. It was established to be a suburban city taking the pressure away from the old capital and became a district linking this old capital to the new communities and capital further away in the desert. Heliopolis was always known for its initiative role in integrating transportation and urban planning being the first transit-oriented city in Cairo which is based on the first tramline in and now being the first district to undergo the motion of traffic development in Cairo.

During the years, Heliopolis turned to be more car-dependent leading to repeated traffic problems, which get solved bit by bit. The most recent traffic development project taking place in Heliopolis left the district with several benefits as well as negative effects. This project includes constructing flyovers, widening streets and changing traffic management regulations, all to decrease the congestion level of the district, enabling easy and smooth mobility within and through the area to connect its surroundings.

Examining the impacts and effects of this project are the main focus of this research. In the following chapter, the methodology of identifying and analyzing the effects of the newly constructed elevated transportation infrastructure in Heliopolis is discussed.

7. Chapter 7: Methodology

Due to the lack of research on this topic in the Egyptian context, this research aims to explore ways to examine the effects of the ETIs on urban travel behavior. The research follows mainly a quantitative approach, with the support of qualitative data in some parts. The approach enables the examination of the topic from different angles, geographically and temporally, to get a wider and more in-depth view of the effects and impacts of the flyovers. Thus, the effects will be examined on the macroscale, which will focus on the city scale (Cairo) and on the microscale, which will focus on the district-scale (Heliopolis). The effects will be identified by comparing several aspects in two temporal periods, one before the ETI construction and one after it. This chapter will discuss the selection of the case study, the data collection, and the analysis approach of both macro and microscales.

7.1. Case study selection

The case study of this research is Heliopolis District in Cairo. Heliopolis is one of the first urban areas in Cairo to face massive urban changes due to the introduction of the traffic development project, which includes the construction of several flyovers and street widening to accommodate these flyovers. This development project faced a lot of criticism from the public, be it Heliopolis residents, heritage activists or concerned Cairenes, leading to several massive social media campaigns opposing the flyover constructions. This brought the area at the center of every discussion about the topic of flyovers in Cairo.

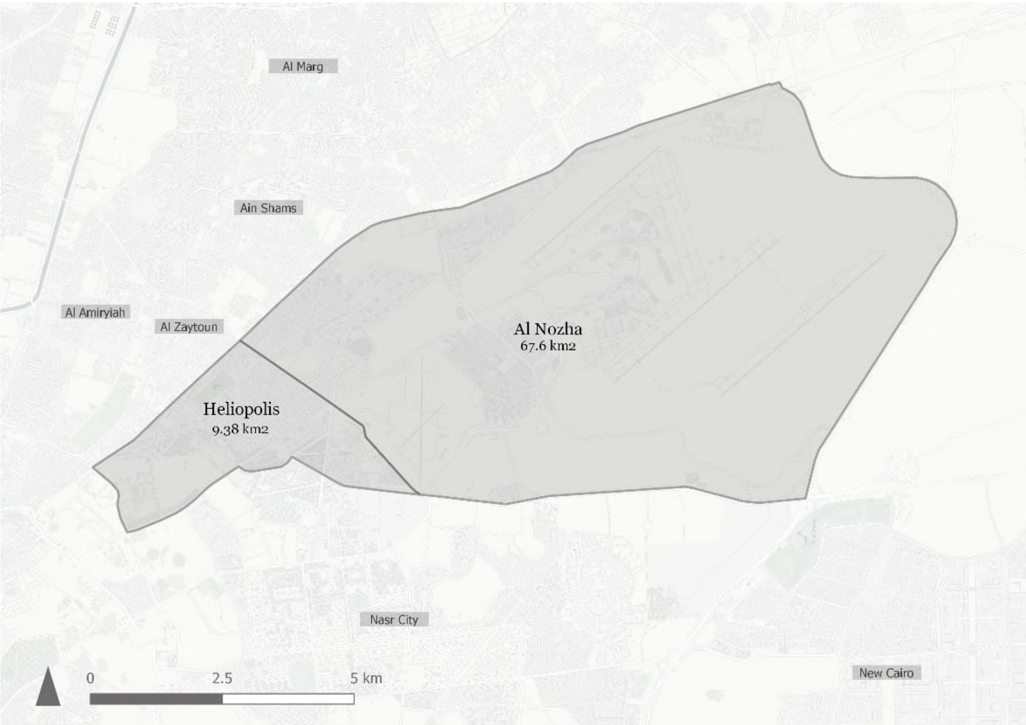


Figure 18: Study Area (Author)

The selection of the case study is based on the novelty of the situation of Heliopolis. With the area being in the foreground of flyover discussions and the construction being recent, more data is available on the project, which enabled the research to get more in-depth insights and cover more aspects than in other areas. As mentioned, Heliopolis is the first district undergoing the new traffic development project, thus taking it as a case study might help in reflecting the outcome of the research on the upcoming traffic development projects of other districts.

By the beginning of the research work, the five flyovers mentioned in the previous chapter were constructed as part of the first phase of the traffic development project in Heliopolis. These five flyovers are the sample that is being studied in this research. Later on, further phases of the project were implemented along with other flyovers in Heliopolis and its surroundings. However, they do not fall under the scope of this specific case study sample.

The flyovers studied in this research are:

1. Midan Al Mahkama Flyover
2. Midan Safeer Flyover
3. New Al Nozha Flyover
4. Almaza Flyover
5. El Marghany Flyover

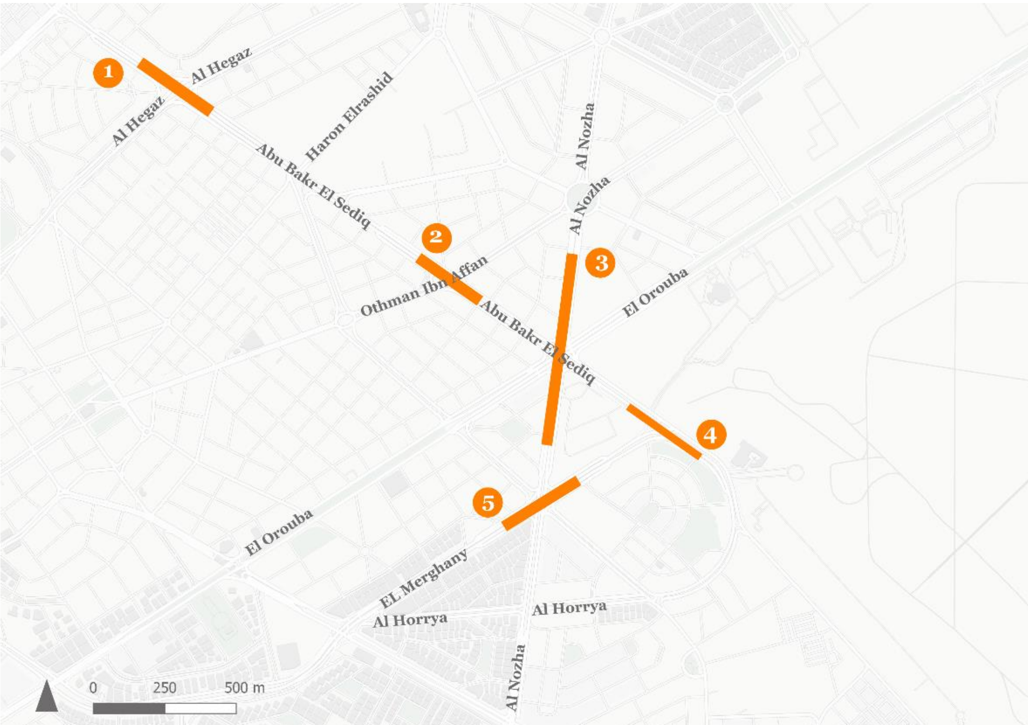


Figure 19: Flyovers to be studied (Author)

7.2. On the Macroscale

As mentioned in the literature review, gathering knowledge and understanding the traffic changes and travel patterns in a city is crucial to be able to quantify the effects of transportation improvements and proposed projects. One way of understanding traffic performances is by analyzing traffic congestion and flow.

In this research, traffic congestion and flow are being analyzed on the city scale of Cairo while focusing on Heliopolis and its immediate surroundings. Two periods will be analyzed one before the construction of the flyovers and one after. The analysis will be done through visualization and numerical analysis. The analysis is mainly based on quantitative data. Due to the novelty of the studied project, a lot of qualitative data such as interviews and documentaries are available on the topic. These data got presented in the background chapter of the case study, Chapter 6, and thus no further primary qualitative data collection through interviews etc. was needed.

7.2.1. Data collection approach

The traffic congestion and flow analysis will be conducted through collecting the travel time data of the study area before and after the construction and comparing them to identify the potential changes influenced by the flyovers. The area to be studied is within a 10 km buffer from the flyovers. This also includes the administrative areas lying with a minimum of 50% within this buffer.

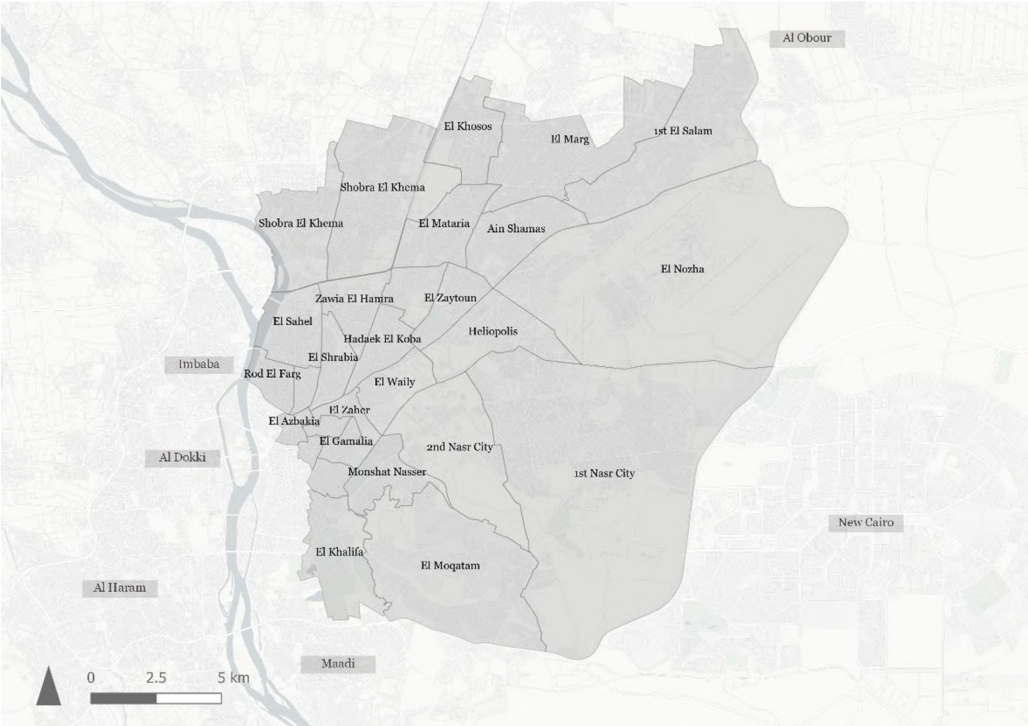


Figure 20: The study area of the macroscale analysis

The travel time of the street network within the buffer zone will be collected through a tool called Distance Matrix from Google Transit. This tool enables the requiring of traffic data history for a specific area. This traffic data history is being collected by Google Transit through the FCD approach explained in the literature review.

To be able to use this tool, specific origin and destination (OD) coordinates must be entered. For this, an OD layer created by Transport for Cairo (TfC) will be used. The OD points on this layer represent public transportation stops that have been recorded throughout a data collection conducted by TfC on the public transportation network of Cairo in 2018. While being an opportunity to be used as OD points for the analysis, the layer is limited to TfC's collected data and the geographical distribution of the public transport network. Thus, these OD points mainly are covering the main streets of the study area rather than inner/residential roads. For the area specified above, there are 1155 origin/destination points.

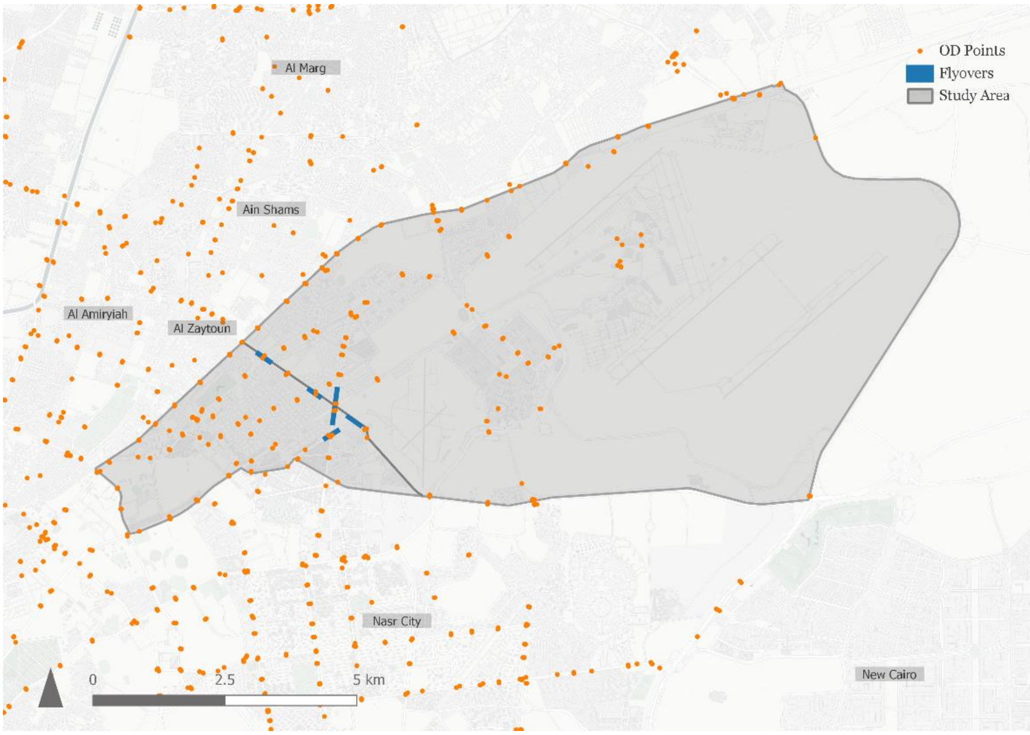


Figure 21: OD Layer (Author)

The result of this process will be the travel time calculated for the distance between each OD pair during several time slots per day in numerical values, one before and one after the flyover construction. The travel time generated by Google Transit is based on the historical FCD collected by Google throughout the period before running the inquiry. The period is related to the road network on which the inquiry is being made; however, the exact period is unknown. The inquiry is based on creating travel time prediction in the future. To be able to produce a travel time prediction, Google uses all the historical data collected on the road network at the time of the inquiry and calculates the average travel time at this time of day, differentiating between weekends and weekdays. Thus, the average travel time generated by Google as a future prediction can be treated as the average travel time of all the historical data gathered by Google on the current road network.

The travel time data before the ETI construction, before September 2019, was previously collected by TfC on all of Cairo's road network in August 2019, one month before the ETI construction. The travel time was requested for nine time slots per day (6:30; 8:00; 9:00; 11:00; 13:00; 15:00; 17:00; 19:00; 21:00) on weekdays. The data after the ETI construction, which is after January 2020, is collected by TfC upon the researcher's request in June 2020 and includes the road network that lies within the buffer zone mentioned above. The same time slots are used to enable the comparison.

The traffic congestion and flow analysis are best done on the most congested conditions of the network; thus, the data was collected from weekdays only. Traffic on weekends usually does not exceed the transportation capacity and is therefore not collected (Goulias, 2016).

7.2.2. Analysis approach

After collecting the travel time data for both periods, the data will be analyzed through a visualization analysis as well as a numerical one. In each approach, the main data analysis will be through comparing the before and after state, identifying potential changes and effects of the flyovers.

The output will be the following:

- Visual analysis through GIS maps visualizing travel speed for each road segment (before and after)
- Numerical comparison between before and after on average travel speed during the day and at different peak hours
- Comparison between the before and after according to travel speed, choke points, peak hours, change in congestion level and location

Visualization analysis

The traffic congestion and flow analysis are based on a visualization analysis algorithm, as explained in the previous chapters of the literature review. This process consists of four steps: Preprocessing, map matching, travel speed estimation and traffic congestion classification (Zhou et al., 2015).

In the **preprocessing** phase, the data will be cleaned. Travel speed less than 0 or higher than 150km/h, as well as abnormal driving directions or outliers, will be removed. After that in the **map matching** step, a script developed by TfC will be used to match the numerical data gathered from Google using the origin and destination points to the existing road network. This step enables the conversion of the separate origin and destination coordinates to geographically correct segments laid out on the current street network. To do this, TfC uses the geographic attributes of their collected public transportation trips. A buffer of three meters from each of the public transportation trips will be created. All the collected travel times between the OD pairs within this buffer will be matched with the geographic attributes of the relevant trip segment and thus laid out on the street network. The output of this step is geographical road segments carrying the travel time data in GIS format.

In the **travel speed estimation** phase, the traffic speed will be calculated for each road segment, using the same script by TfC, to present an average travel speed. According to the travel speed, **a traffic congestion classification** will be applied to present the different traffic states. The different classifications will then be visualized as colored segments to represent the congestion level of each one, as seen in the examples discussed in the literature review.

To make the visualization analysis more manageable, the geographical data will be divided according to the three main peak periods, representing two maps for each peak period before and after the flyover construction. One map will be on the scale of the identified study area and one zoomed in focusing on Heliopolis and its immediate surroundings.

The chosen peak period will be:

- Morning peak: 6:30 – 9:00
- Off-peak: 11:00 – 13:00
- Evening peak: 15:00 – 19:00

Based on the maps showing the congestion levels before and after the flyover construction, a comparison will be made, identifying the area of congestion in each map, the change of the congestion level and location between the two time periods and the change in chokepoints if applicable.

The first data collection steps of preprocessing, map matching and travel speed estimation are going to be done by TfC, due to the high technical skills needed and limited timeframe of the thesis. The steps starting from the traffic congestion classification until the end of the data collection and analysis are going to done by the researcher.

Numerical analysis

With the numerical data collected from Google Transit, the average speed of the street network of Heliopolis before and after the flyover construction will be calculated. The average travel speed will be compared in the beforementioned peak periods, identifying the changes between them. Furthermore, it will be analyzed throughout the whole day to identify the peak hours and compare the peak hours before and after the construction.

7.3. On the Microscale

When implementing transportation development projects, it is important to examine their effects, not only on the macroscale, but also on the microscale. In this research, the effects of the ETIs on the microscale are being examined on the travel behavior of the flyover users.

There are several data collection and analysis approaches when it comes to travel behavior research; most of them already mentioned in the literature review. In this study, the travel behavior analysis on the microscale is being based on a travel behavior survey.

7.3.1. Data Collection approach

Based on research, travel behavior changes are commonly studied using travel behavior surveys. Best survey type used is a household survey, however, due to the current situation of the pandemic limiting the fieldwork and due to the scope and timeframe of the thesis, an online survey will be used.

The aim of this survey is to gather data regarding the effects of the ETI on travel behavior changes before and after the flyover construction. The survey targets anyone using the flyovers, such as residents of Heliopolis, visitors, or workers. It follows mainly a revealed preference approach, as it is based on comparing the behavior from the past before the flyovers with the behavior of the present. However, some questions in the survey follow the stated preference approach, testing the potential future behavior changes.

The travel behavior changes are complex and appear over the short and long term. In this research, the focus is mainly on the short-term changes which include changes in the route choice, mode choice, trip frequency, time of day the trip is made, trip chaining and destination choice (Carrion and Levinson, 2011; Goulias, 2016). Some longer-term impacts might be briefly mentioned, such as the potential increase in car ownership and possible change in future trip frequencies (Dowling and Colman, 1995).

The questionnaire is divided into four main sections, demographic section, relation to Heliopolis section, travel behavior changes section and general satisfaction section. The travel behavior section is divided into three sub-sections, one gathering general mobility information about the respondent, one gathering the travel behavior before and one gathering the travel behavior after the ETI construction.

Generally, the questions aim to gather data on travel behavior descriptors (Goulias, 2016), including:

- Trip distance
- Trip purpose
- Trip frequency
- Travel time
- Travel cost
- Route choice
- Mode choice
- Connectivity
- Trips affected by ETI (motorized and non-motorized trips)
- Flyover satisfaction

In general, most questions are quantitative questions, while some of them have follow-up qualitative questions, gathering some insights through qualitative data. The full questionnaire is available in Appendix A.

The population of Heliopolis is 141 903 and of Al Nozha district is 238550 residents (Cairo Governorate, 2016; City Population, 2018), with a total of 380453 residents. Nonetheless, the target of the survey is anyone using the flyovers, which includes visitors and workers etc. Due to the lack of data regarding the number of daily visitors and workers to Heliopolis, the sample size was calculated to accommodate the maximum number of population size possible. To achieve a confidence level of 95% and a margin of error of 5%, the sample size is a minimum of 385 participants.

7.3.2. Analysis approach

The survey results will be analyzed quantitatively, using a statistical analysis approach. The statistical analysis will be done through methods such as multinomial logit model analysis using SPSS, pivot tables and regular chart analysis using Microsoft Excel. The analysis will follow the travel behavior descriptors mentioned above. Each of these descriptors will be analyzed with the tool fitting the gathered data.

The multinomial logit model analysis will be used to identify the association between several independent variables with the travel behavior descriptors (dependent variables) getting affected by the flyovers. Using such a statistical approach for the analysis creates results that are more reliant than other qualitative analysis approaches. As for the pivot table analysis, several variables will be analyzed to establish potential relations between them and to understand the certain effects on specific variables.

To identify which of the travel behavior descriptors will be further analyzed through a multinomial logit model or pivot tables, the data of each aspect from before and after will be compared and analyzed through regular chart analysis. Only the aspect which shows a significant change between the two periods will be further analyzed using the statistical analysis approaches. Moreover, the regular analysis through charts is used to further understand the data and draw conclusions on several results that do not need advanced statistical analysis.

The following aspects are to be analyzed:

- Trip purpose
- Trip distance
- Trip duration
- Trip frequency
- Travel cost
- Route Choice
- Mode choice
    - Main Modal share
    - Modal share for Heliopolis destinations
    - The modal share of affected trips
    - Modal interchange within a trip
    - Changes in non-motorized transport (NMT)
    - Willingness to shift to the private car after flyover construction
- Connectivity
- Trips affected by the flyovers
- Flyover Satisfaction
    - advantages/disadvantage of the flyovers
    - alternative solutions suggested by the participants

In this chapter, the methodology is explained, linking each method to the approaches discussed in the literature. In the following chapter, the results of implementing the mentioned methods on the macro and microscale are presented.

8. Chapter 8: Findings and Analysis

This chapter is divided into two main sections, one discussing the macroscale and one the microscale. Each of the sections presents the data output from each method and the analysis conducted on the collected data.

8.1. On the Macroscale

8.1.1. The Data

The result of the Distance Matrix tool ran by TfC on the study area is a table containing each origin and destination pair, as well as the coordinate of each point and the distance between them. Moreover, the travel time (duration) between the two points, once before the ETI construction (08/19) and once after (06/20), and the time interval in which the travel time was recorded, is included.

od_pair_id	o_id	d_id	o_coords	d_coords	time_interval	distance	0819_duration	0620_duration
loitering.movi	loitering.m	ringside.tir	30.1387029	31.325540534	6:30:00	172	43	49
ringside.tiny.r	ringside.tir	styled.ope	30.13727684	31.323830429	6:30:00	409	89	95
styled.operati	styled.ope	jolt.evoke.	30.13392915	31.312162972	6:30:00	1325	245	282
jolt.evoke.sca	jolt.evoke.	certainly.d	30.12980554	31.3083122"	6:30:00	453	100	134
certainly.dum	certainly.d	complies.c	30.1274945	31.3070918"	6:30:00	144	35	49
complies.clos	complies.c	pave.glitz.l	30.1267685	31.300568"	6:30:00	840	230	229
pave.glitz.brit	pave.glitz.l	organist.hu	30.1227666	31.3041028"	6:30:00	608	136	167
loitering.movi	loitering.m	ringside.tir	30.1387029	31.325540534	8:00:00	172	50	58
ringside.tiny.r	ringside.tir	styled.ope	30.13727684	31.323830429	8:00:00	409	107	105
styled.operati	styled.ope	jolt.evoke.	30.13392915	31.312162972	8:00:00	1325	267	295
jolt.evoke.sca	jolt.evoke.	certainly.d	30.12980554	31.3083122"	8:00:00	453	98	129
certainly.dum	certainly.d	complies.c	30.1274945	31.3070918"	8:00:00	144	40	47
complies.clos	complies.c	pave.glitz.l	30.1267685	31.300568"	8:00:00	840	246	213
pave.glitz.brit	pave.glitz.l	organist.hu	30.1227666	31.3041028"	8:00:00	608	141	154
loitering.movi	loitering.m	ringside.tir	30.1387029	31.325540534	9:00:00	172	52	67
ringside.tiny.r	ringside.tir	styled.ope	30.13727684	31.323830429	9:00:00	409	105	108
styled.operati	styled.ope	jolt.evoke.	30.13392915	31.312162972	9:00:00	1325	259	290
jolt.evoke.sca	jolt.evoke.	certainly.d	30.12980554	31.3083122"	9:00:00	453	96	131
certainly.dum	certainly.d	complies.c	30.1274945	31.3070918"	9:00:00	144	39	49
complies.clos	complies.c	pave.glitz.l	30.1267685	31.300568"	9:00:00	840	241	214
pave.glitz.brit	pave.glitz.l	organist.hu	30.1227666	31.3041028"	9:00:00	608	126	166

Table 6: Data Results of Distance Matrix Tool

There are 1155 origin/destination points across the study area, 1719 OD pairs, and 14033 instances. The time intervals in which the data got recorded are nine intervals: (6:30; 8:00; 9:00; 11:00; 13:00; 15:00; 17:00; 19:00; 21:00). The distance is measured in meters and the duration in seconds.

As explained in the methodology, the data undergoes several steps to be able to get used in the visualization analysis. After the preprocessing, the map matching, the travel speed estimation, and the traffic congestion classification, the data is turned into geographical data in GIS format. Each OD pair is converted into segments, carrying the travel speed data, and then classified into its congestion level category.

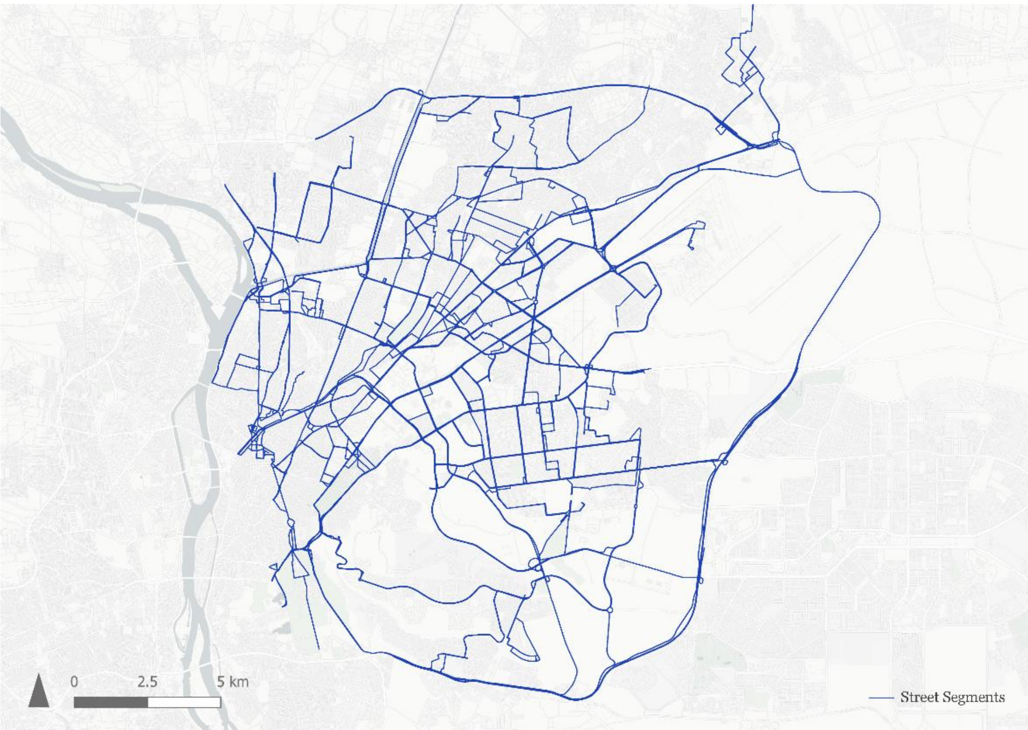


Figure 22: Street Segments converted from OD pairs (Author)

These congestion level categories are visualized through colors to reflect the travel speed of each segment. The usual colors used in Google Maps, for example, are three colors, red, orange, and green, red being the most congested state. In this research, five colors are used to minimize the range of each congestion category and thus make it more sensitive for representing any changes in congestion levels.

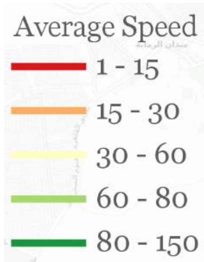


Figure 23: Color categories for average travel speed in km/h

Data Limitation

The limitation of using the FCD from Google Transit in this research is that the flyovers have been constructed recently. Thus, the street network projected on Google Maps is not fully updated with these new road changes yet. By the time of the data collection, only two flyovers out of five were updated on Google Maps. This might have led to some inaccuracies in the data, especially for the data on streets with the flyovers. However, the main aim of this research is to analyze the effects of those flyovers on the street network as a whole, taking the scales of Cairo and broader Heliopolis. Thus, the effects of these flyovers on the road network will be captured through the data on the surrounding streets, which did not undergo any road changes.

8.1.2. The Analysis

As mentioned in the methodology, the analysis of the urban travel behavior on the macroscale is done through visualization analysis and a quantitative numerical one. Through the visualization analysis, the traffic flow and congestion are being analyzed during three peak periods. Each period is analyzed once with the data before the flyover construction and once with the data after it. They are analyzed on the Cairo scale and the Heliopolis scale with its immediate surroundings.

As for the numerical analysis, the average speed of Heliopolis is being compared through the main three peak periods, as well as throughout nine time slots throughout the day, to identify the peak hours.

Visualization Analysis

Morning Peak Period – MPP (6:30 – 9:00)

Through analyzing both traffic maps, it is clear that the congestion shifted more towards the North – West of Heliopolis, affecting areas such as Al Horeya Street and Ain Shams district.

In the south, the congestion shifted further away from Heliopolis, concentrating on Al Tayaran Street and the area around it, which might make the connection to Nasr City a bit harder. The connection of Al Nozha and Al Thawra street is more congested after the construction, creating a choke point in Al Thawra street leading to Al Suez Road.

Moving closer to the flyovers, the connection linking Heliopolis to Al Zatoun and Al Amiryiah area through Abu Bakr then Ibn Al Hakem and Al Kablat Street is slightly more congested after the flyover construction. On the other hand, Salah Salem Corridor and Al Orouba Street are less congested in some parts, making the commute to central Cairo a bit easier.

During the morning peak, the areas seemingly affected by the flyovers on the scale of Cairo are mainly the districts and neighbourhoods directly surrounding Heliopolis, such as Ain Shams, Al Zaytoun, Nasr City and Al Amiryah. But also, some major corridors connecting the East to the West of Cairo, like Salah Salem Corridor.

Zooming in to Heliopolis, it is visible that the average congestion levels of the district slightly decreased. Most of the congestion moved out of Heliopolis to the neighbouring areas. The main positively affected streets are Al Hegaz, Al Orouba and Al Khalifa Al Maamoun street. However, during the morning peak, Al Nozha street is very congested, although there are two flyovers constructed in two of its intersections. Moreover, Gesr Al Suez and Youssef Abbas street are more congested than before.

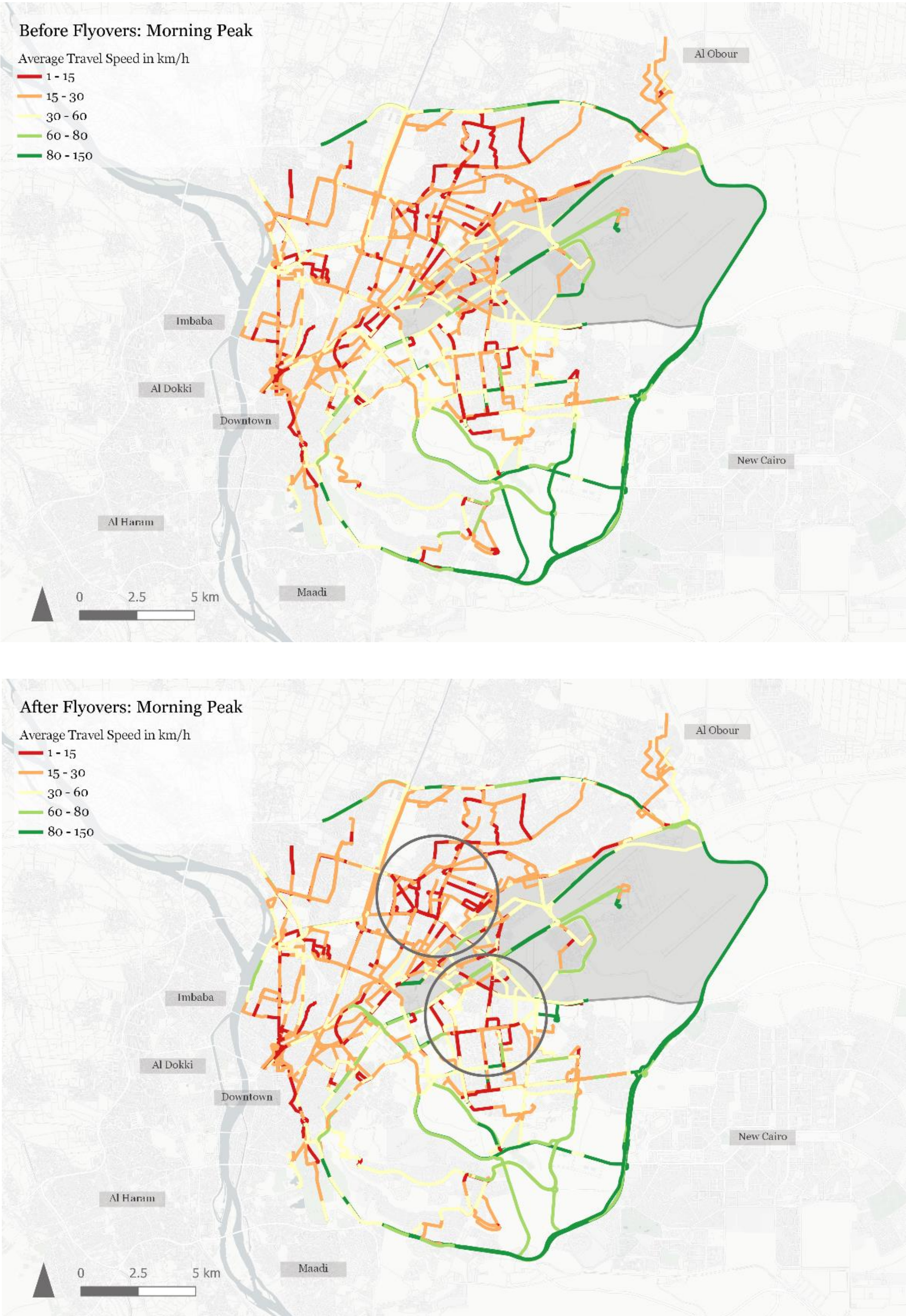


Figure 24: Study Area Congestion: Before & After, Morning Peak (Author)

Figure 25: Heliopolis Congestion: Before & After, Morning Peak (Author)

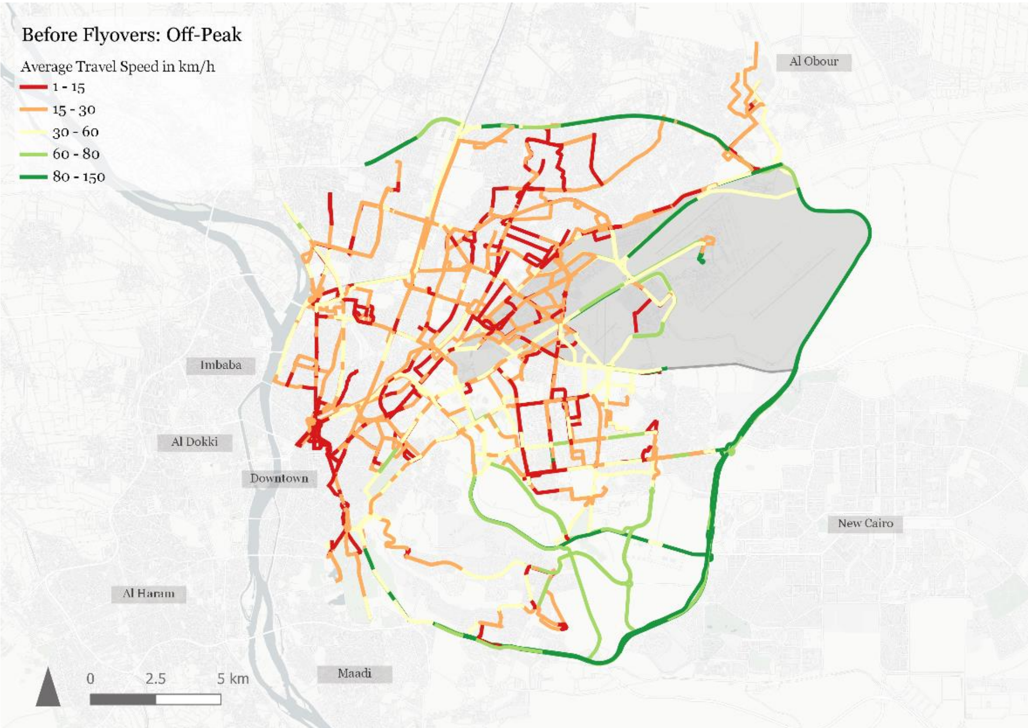
Off-Peak Period – OPP (11:00 – 13:00)

Like in the morning peak, the congestion shifted more to the North- West of Heliopolis to Al Horeya Street and Ain Shams District.

In the off-peak, the connection to Sheraton through Cairo International Airport Road is slightly more congested than before. Moreover, Al Nozha street became more congested after the intersection with Al Thawra street to the South. A slight choke point after Al Thawra street and at the beginning of Suez Road appeared. However, the other connection to Sheraton through Al Hegaz Street and Abdel Hameed Badawy street is less congested after the flyover construction. This decreased and moved the chokepoint from the intersection of both streets, a bit to the South ending at Al Nozha and Al Hegaz intersection. In addition to that, Salah Salem Corridor is also slightly less congested in some areas, making the accessibility to central Cairo smoother.

In the off-peak, the most seemingly affected areas on the scale of Cairo are Ain Shams, Sheraton, the link to Suez Road and Salah Salem Corridor.

On the scale of Heliopolis, the overall average speed did not really change. Some parts became less congested while others decreased in travel speed. On the one hand, it is visible that the congested parts moved to the edges of the districts, such as Gesr Suez, Al Nozha and Youssef Abbas street. On the other hand, the congestion level decreased in the area around MerryLand Park and Khalifa Maamoun street. In addition to that, the intersections between Al Hegaz and Abu Bakr street as well as Al Nozha and Abu Bakr street are less congested than before. These intersections are the ones which got solved with flyovers construction.



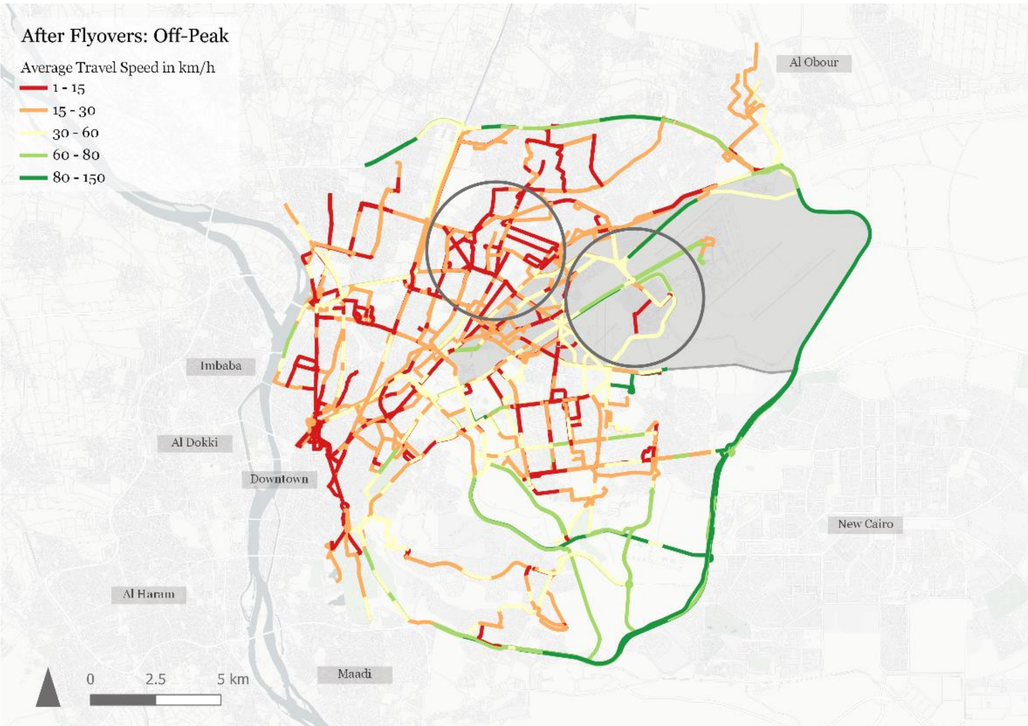


Figure 26: Study Area Congestion: Before & After, Off-Peak (Author)

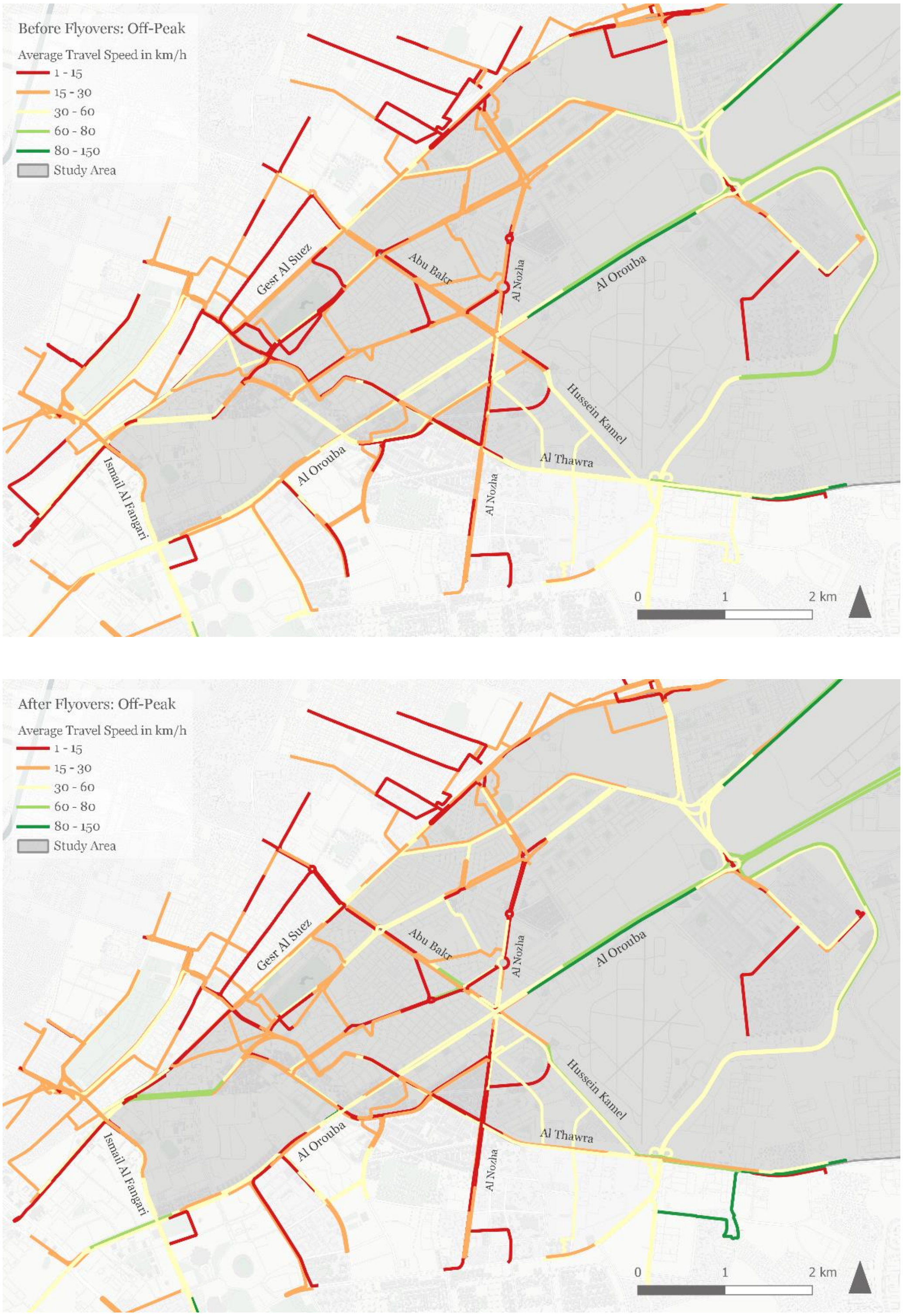


Figure 27: Heliopolis Congestion: Before & After, Off-Peak (Author)

Evening Peak Period – EPP (15:00 – 19:00)

Same as in the morning and off-peak, the congestion shifted from Heliopolis to the North-West area, reaching to Al Horeya and Al Kablat street as well as Ain Shams area. The west of Heliopolis and Joseph Tito Street shows a slightly lower travel speed, affecting the entrance of Heliopolis from the North through the Ring Road.

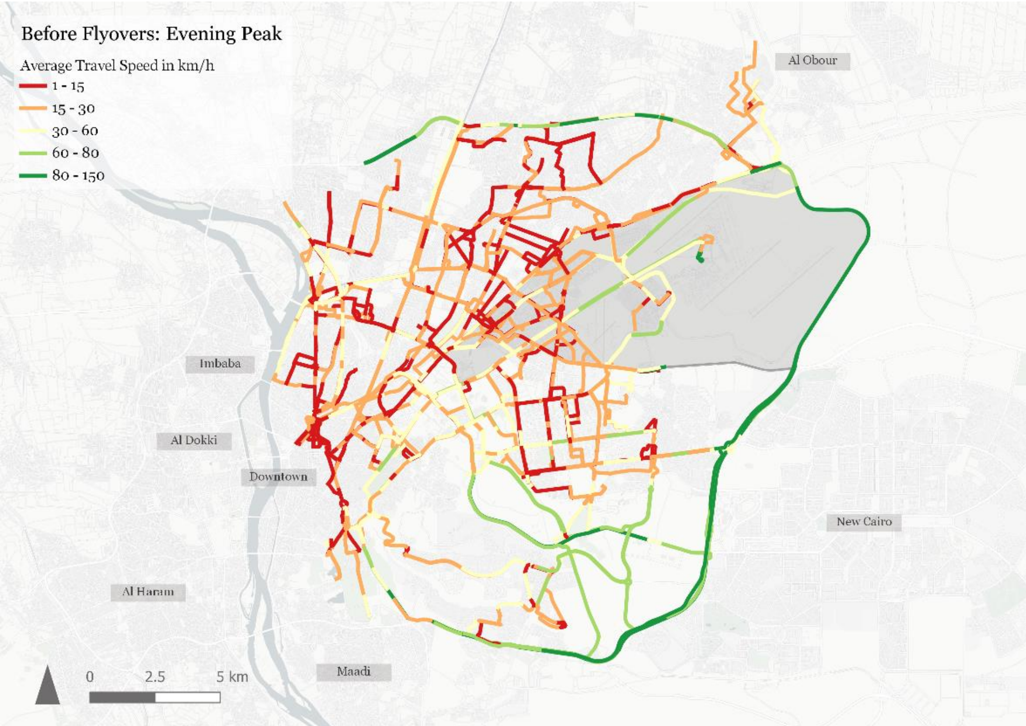
The congestion also shifted from Heliopolis to the South. The entrance to Nasr City through the South of Al Nozha street is more congested. Moreover, Emtedad Ramses Corridor is showing a reduced travel speed, making the connection between Heliopolis, Nasr City and New Cairo a bit slower.

While Gesr Suez and Salah Salem corridor stayed in the evening peak the same between the before and after states, Youssef Abbas street in Nasr City branching from Salah Salem Corridor is more congested now.

Al Nasr Road and Al Taqa Street are less congested from the North. This clears the way to the Suez Road and makes the connection easier. As for the connection between Heliopolis and the Suez Road through Al Thawra street, the travel speed increased, reducing the congestion in that area. As a result, the choke point that was once at the beginning of the Suez road got shifted back to the intersection of Al Nozha with Al Thawra street.

The main seemingly affected areas during the evening peak are Ain Shams, Al Zatoun, Nasr City and Suez Road.

Looking at Heliopolis, several parts decreased in the congestion level, while the congested areas moved to the borders of the district. Streets like Abu Bakr, Khalifa Al Maamoun, Al Nozha, Hussein Kamel, Omar Ibn Al Khattab, Al Thawra and the beginning of Al Nasr Road from Suez Road's side became less congested. However, Matareya, Salim Awal, Youssef Abbas and Gesr Suez street are more congested now.



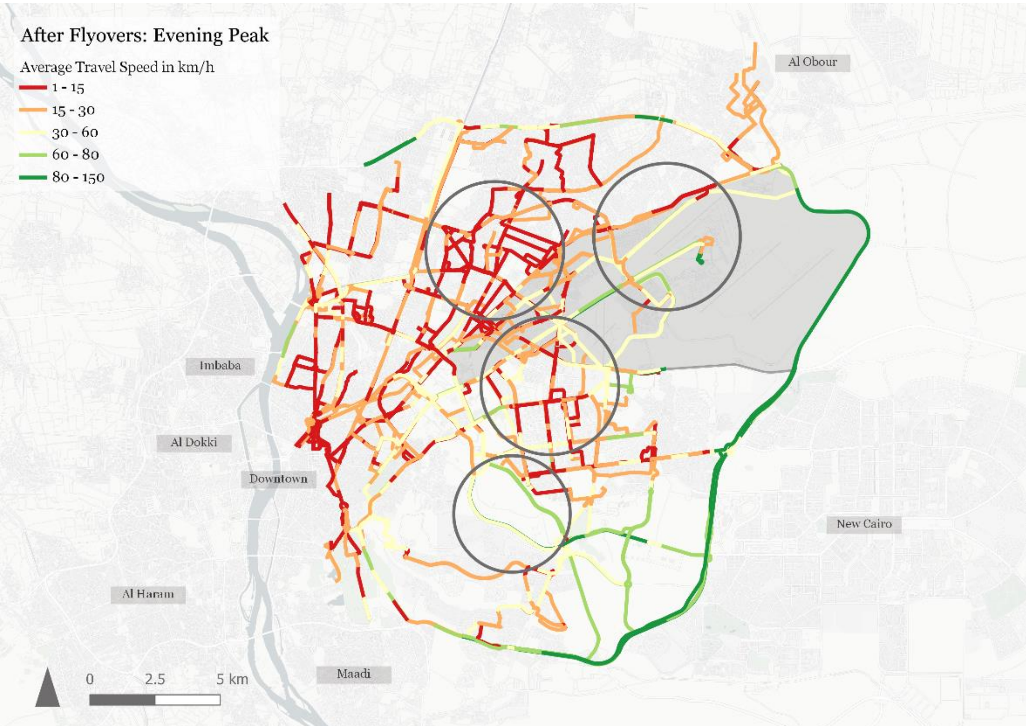
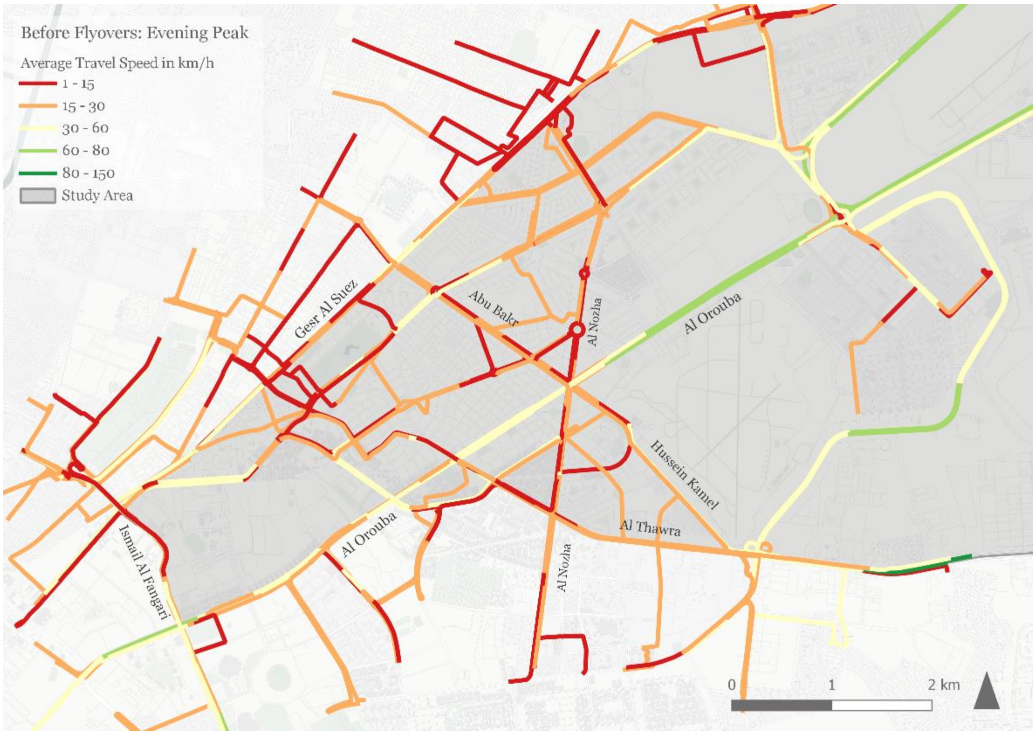


Figure 28: Study Area Congestion: Before & After, Evening Peak (Author)



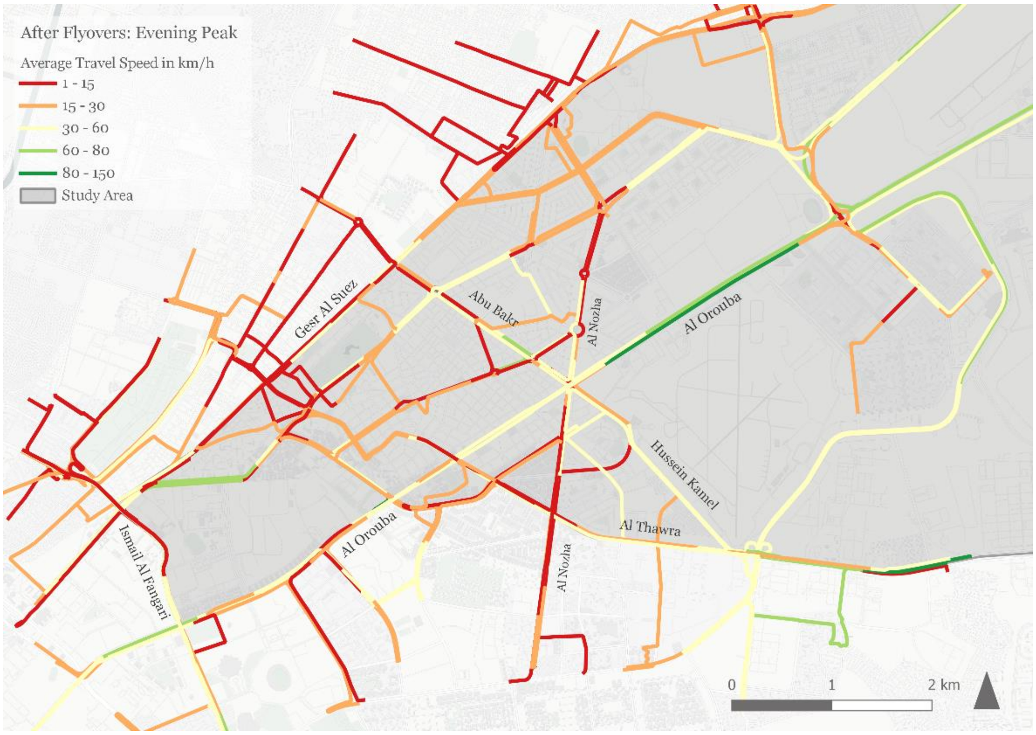


Figure 29: Heliopolis Congestion: Before & After, Evening Peak (Author)

Numerical Analysis

After comparing the before and after state during the three main peak period through a visual analysis approach, it is of value to take a more in-depth look through a numerical one. Two of the conclusions that could be made from the visualization analysis are the following:

- Most affected peak period that showed a change between the before and after state was the evening peak, then the morning peak and lastly the off-peak.
- The most congested peak period is the evening peak, then the off-peak and the least is the morning peak.

Looking at the numbers, the same two statements can be made. After calculating the average speed on the streets of Heliopolis, it evident that on the one hand, the evening peak is the most congested period out of the three, but on the other hand, it is the most affected one. The average travel speed in the evening peak increased from an average of 25.4 to 26.2 km/h. As for the off-peak, it is the least affected period, due to the numbers, the travel speed decreased around an average of 0.2 km/h. For the morning peak the travel speed increase about an average of 0.6 km/h than before the flyover construction.

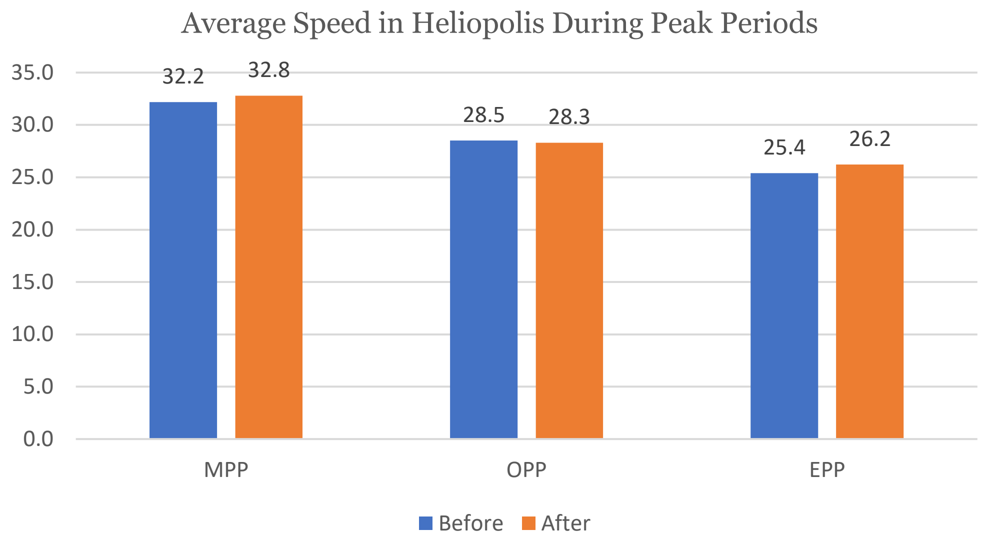


Figure 30: Average Travel Speed in Heliopolis during different peak periods (Author)

To be able to identify the peak hours before and after the flyover construction and compare them, an average travel speed for Heliopolis was calculated for nine time slots during the day.

As seen in the chart below, there were two main peak hours before the flyover construction in Heliopolis, one at 9:00 a.m. and one from 5:00 till 7:00 p.m.

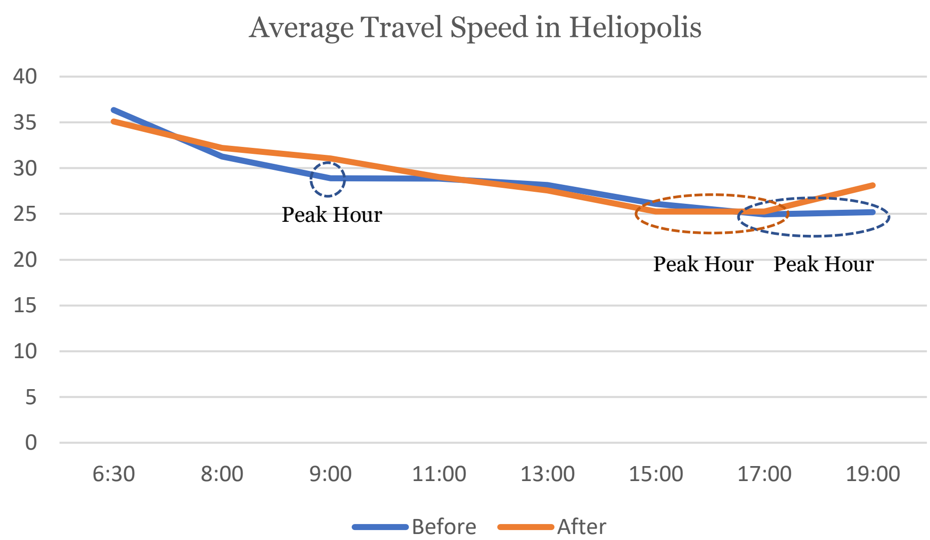


Figure 31: Average Travel Speed in Heliopolis throughout the day (Author)

After the flyover construction, the peak hour in the morning was mitigated and the peak hour in the evening shifted from starting at 5:00 p.m. to starting at 3:00 p.m. and continuing till 5:00 p.m. After that, the traffic gets better, and the travel speed increases.

During all peak periods on the scale of Cairo, there is a visible shift of congestion from Heliopolis towards the neighbouring areas. The affected areas are to the North, such as Sheraton, to the North-West, such as Ain Shams, Al Zatoun, Al Amiryah, as well as to the South, like Nasr City. However, after the completion of the projects in Heliopolis, some of the affected areas or streets mentioned are either undergoing or completed similar traffic development projects to eliminate the congestion shifted towards them. Eight flyovers are already constructed in areas surrounding Heliopolis (Sabry, 2020). Three are built in Nasr City, on streets Youssef Abbas, Abbas El Akad and Tayaran. In Al Zaytoun and Al Amiryah, five more flyovers are constructed, such as Sawah, Al Horreya, Al Helmeya and Mastard flyovers. The construction of these new projects in the neighboring areas of Heliopolis ended in May 2020 (Sabry, 2020), which is before the data collection of this research and thus are reflected in the analysis.

In addition to the surrounding areas, main corridors linking to several parts of Cairo showed changes in their congestion level, such as the beginning of the Suez Road, which eventually links to the New Urban Communities, as well as Salah Salem which connects to central Cairo.

According to the visualizations and the numbers, overall, the evening peak is the most congested period of the day, after it, the off-peak and the least congested period is the morning peak. Moreover, the most affected peak period showing a change from before and after the flyover construction are the evening peak, followed by the morning peak and lastly the off-peak. The effects on the congestion level comparing the peak periods are positive. Also, the peak hours slightly changed, either by being mitigated or by changing the time of day.

8.2. On the Microscale

8.2.1. The Data

The survey was launched on the 3rd of June 2020 and lasted till the 19th of July 2020. The number of online survey respondents collected is 432, exceeding the targeted sample size of 385 participants. These responses were gathered through sharing the survey online on many social media groups and platforms, which include Heliopolis residents and supporters. The survey was designed in Arabic to increase the target audience and, thus, the number of responses. For the analysis, the results were translated into English.

The survey responses are available in tabular format, including mostly quantitative data, but also some qualitative data as responses to open-ended questions in the survey.

At the beginning of the survey, two sections are aiming to categorize and classify the respondents based on different demographic or background data, demographic and relation to Heliopolis section.

Demographic section

The survey was targeting age groups older than 18 years and categorized them into six age groups (see chart). Each of these age groups got represented in the survey, some more than others. While having the age group of 26 to 35 years as a majority with 40%, ages above 65 years are represented with only 0.7%. In general, the younger age groups have a higher response rate than the older ones. On the one hand, this could be based on Cairo having mainly a young population (World Population Review, 2020), and on the other hand, it could be based on the survey being online. Usually, younger generations are more involved in technology than older ones.

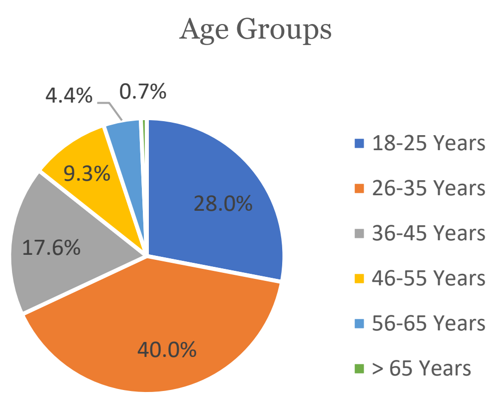
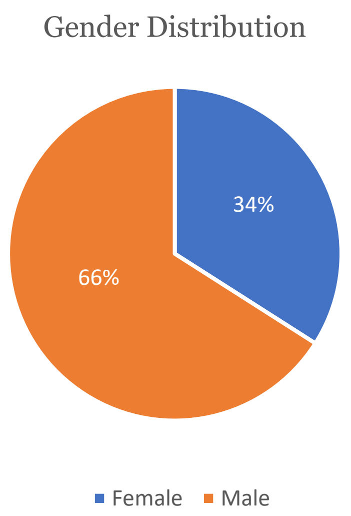


Figure 32: Age Groups (Author)



As for the gender, the survey was completed by 66% male and 34% female respondents. This distribution varies a bit from the gender distribution of Heliopolis, 49.2% females and 50.8% males, and from Cairo's gender distribution of 48.1% females and 51.9% males (City Population, 2018).

Figure 33: Gender Distribution (Author)

The majority of the people who took the survey are employed, followed by students and then unemployed respondents, either looking or not looking for jobs. This percentage slightly reflects the reality of the Egyptian population, as most Egyptians are employed, having only a 7.9% unemployment rate (CAPMAS, 2019).

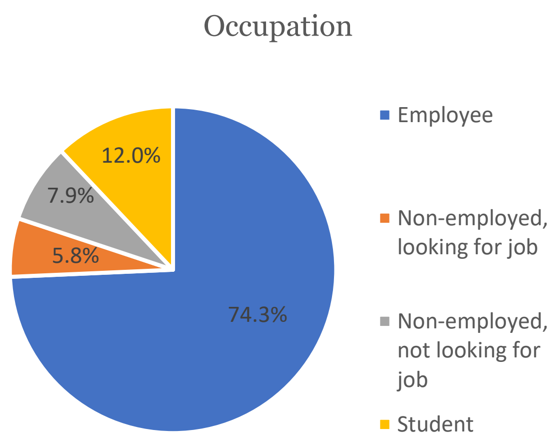


Figure 34: Occupation (Author)

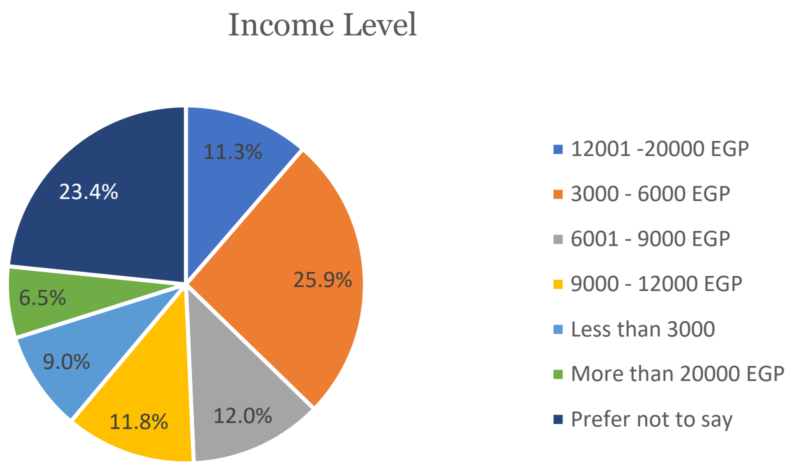


Figure 35: Income Level (Author)

For the income level question, 23.5% of the respondents preferred not to say. This percentage is within the average of travel behavior surveys across the world (Goulias, 2016). As for the rest of the income level options, all of them are more or less represented evenly, except the income level from 3000 – 6000 EGP having the most responses with a percentage of 25.8%. And the income levels below 3000 EGP having 9% and above 20000 EGP having 6.5% are both represented with the least percentages.

This indicates that most of the people who took the survey, which are mainly residents, are belonging to the middle and upper-middle-income class, which represents the social classes associated with Heliopolis.

Relation to Heliopolis Section

Most respondents of the survey are residents of Heliopolis, with 53.1%, followed by visitors, 35.5%, and people working there. Heliopolis has several commercial areas and thus attracts a lot of visitors to the area.

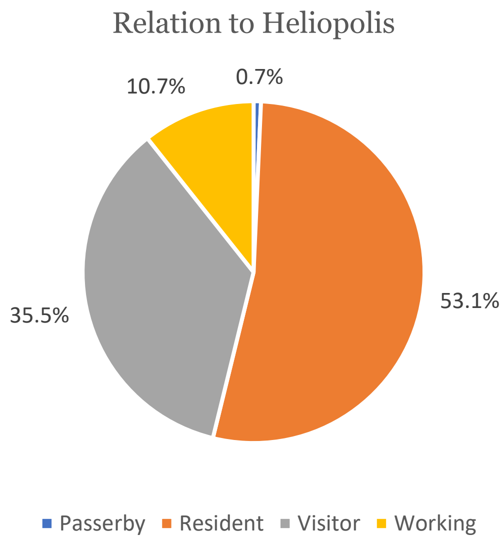


Figure 36: Relation to Heliopolis (Author)

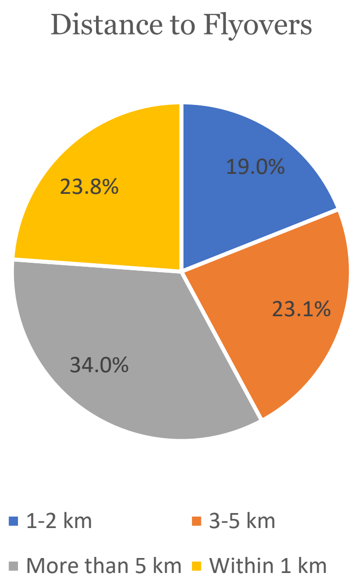


Figure 37: Destination Distance to Flyovers (Author)

A question asking about the distance of the respondent's destinations in Heliopolis to the flyovers was added. This question investigates if the distance to the flyovers has a role in the flyovers affecting the travel behavior and might help in categorizing the most affected groups based on this aspect.

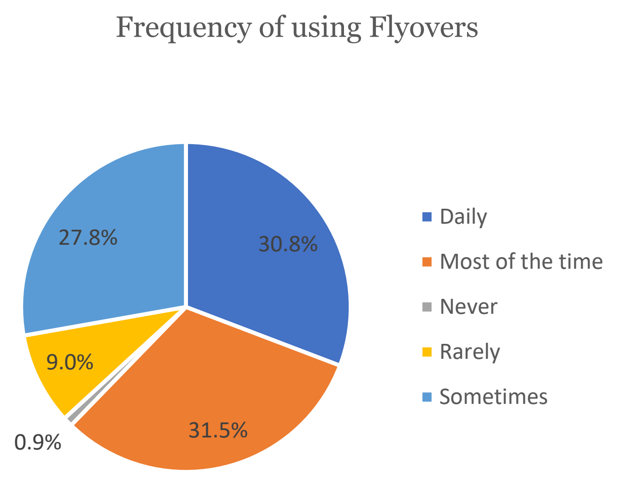


Figure 38: Frequency of using Heliopolis Flyovers (Author)

The last question of this section was directed to the frequency of people using the flyovers. This gives an indicator if the frequency of using the flyovers is associated with people getting affected. The majority of the respondents use the flyovers on a daily basis as well as most of the time. The least percentage was for people using them rarely and people never using them. Responses that stated that they never used the flyovers, which are 0.9%, were removed from the sample, due to the target of the survey being people using the flyovers.

8.2.2. The Analysis

As mentioned before, the survey aimed to gather data about travel behavior changes, the effect of the flyovers on travel and preliminary user satisfaction on the flyovers.

In the analysis, each of the travel behavior aspects identified in the methodology was analyzed through various methods such as qualitative and quantitative methods like regular tools for data analysis, statistical approaches such as multinomial logit models and pivot tables and charts. The aim is to draw conclusions for each aspect and potentially find some links between them. All results of the multinomial logit models in this section are calculated with a confidence level of 95% unless stated otherwise. The full results of any of the following multinomial logit models are in Appendix B.

Trip Purpose

To get information about the trip purpose to/from/within Heliopolis, the respondents answered a series of questions to identify the top three destinations related to Heliopolis, the main mobility mode used to arrive there, and the type of trip length. As a result, the main three destination purposes are work, visiting friends/family members and shopping. Fourth in line comes the leisure and sports purpose.

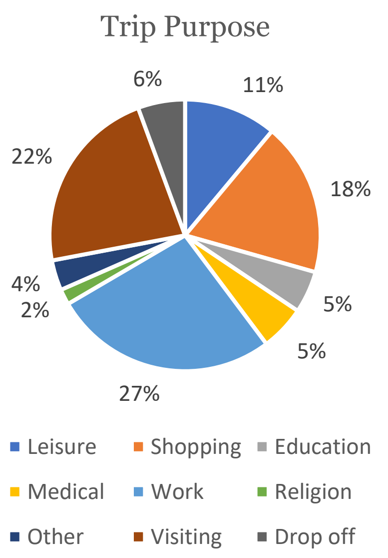


Figure 39: Trip Purpose (Author)

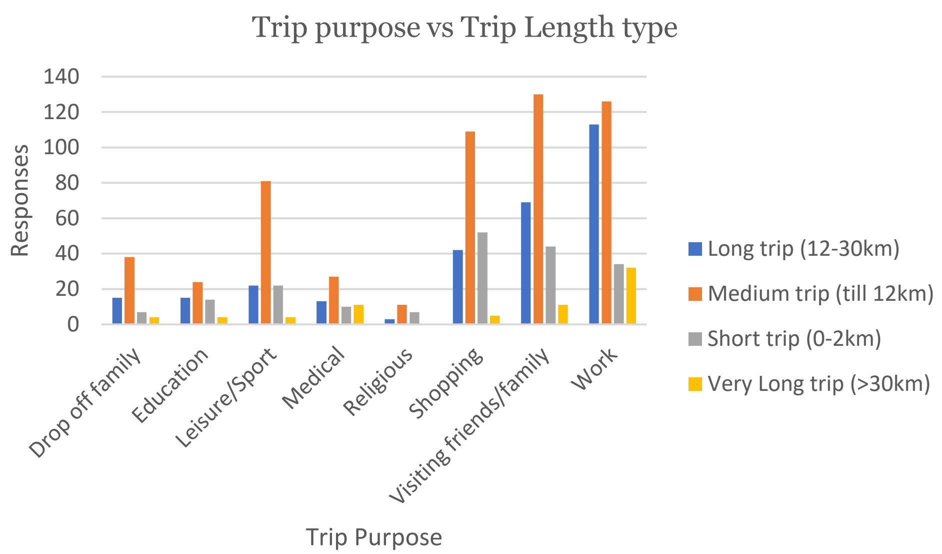


Figure 40: Chart from Pivot table: Trip Purpose vs Trip Length Type (Author)

For each of these destination purposes, the respondents have a different trip length they need to take to arrive there. Based on the data, people making long and very long trips are mainly going to work, which is understandable since the work location does not always happen to be near the residency. However, most of the work trips in the sample has a medium followed by a long trip length.

For shopping, however, people tend to choose the nearest commercial area to their homes to get their daily needs; thus, most short trips are for shopping purposes. As for visiting their friends and family, most of their trips are medium-length trips, same as in leisure and sports trip purposes. For medium trips, the trip purposes are diverse since the 50% of trips done by the sample are medium length trips (see Figure 41). Hence, these trips can vary from work, visiting friends and family to shopping and leisure.

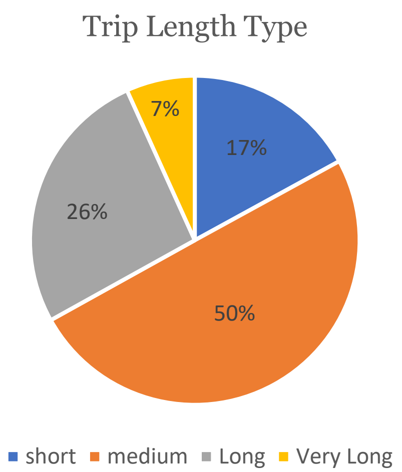


Figure 41: Trip Length Type Distribution (Author)

Trip Distance

The survey asked about the change in trip distance from before to after the flyover construction. The question was a multiple-choice question with three choices: the trip became longer, shorter or stayed the same. As a result, for around 79.6% of the respondents, the trip distance changed. The majority, 45.3%, said that the trips became shorter, followed by 34.3% who said that it became longer.

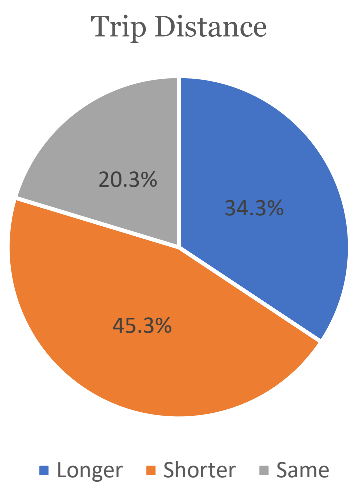


Figure 42: Change in Trip Distance (Author)

Through creating several Pivot Tables, it was possible to identify which groups said it was longer and which shorter.

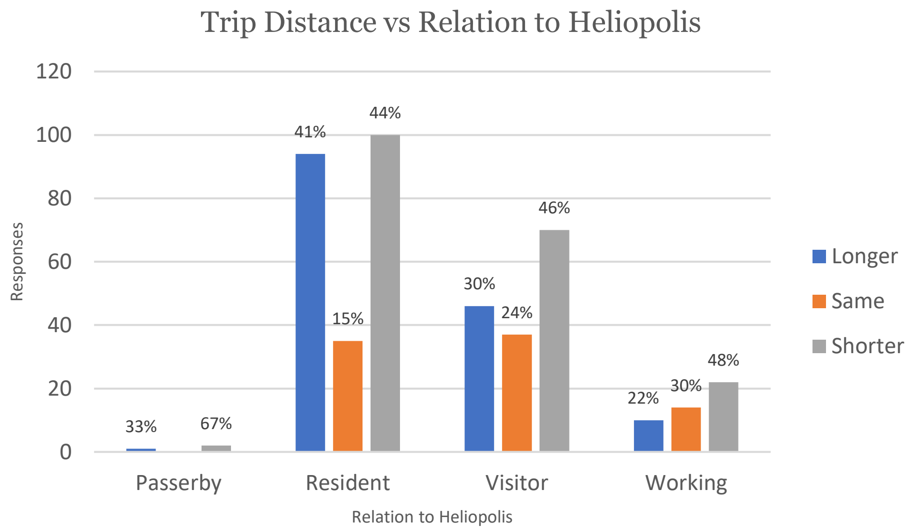


Figure 43: Chart from Pivot table: Trip Distance vs Relation to Heliopolis (Author)

For the Heliopolis residents, the percentage of people saying longer vs shorter are very close to one another. At the same time, for visitors, it is evident that the majority of them perceive the trips shorter after the flyover construction, same for people coming to Heliopolis to work.

In conclusion, possibly most trips from/to Heliopolis became shorter, while some internal trips within Heliopolis might have increased in the distance.

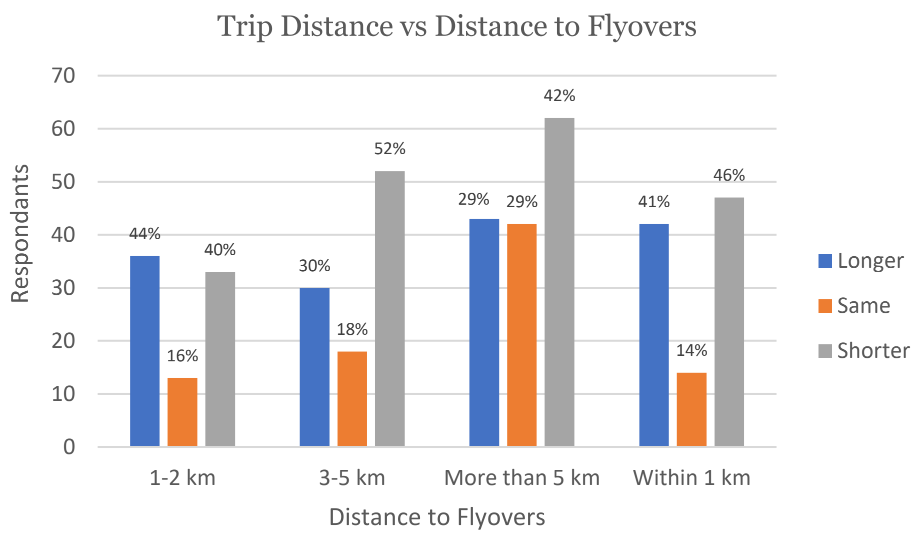


Figure 44: Chart from Pivot table: Trip Distance vs Destination Distance to Flyovers (Author)

Furthermore, the change in trip distance is compared to the distance of the respondents' destinations in Heliopolis to the flyovers. Based on the data, for people with destinations within a 2 km distance from the flyovers, the difference between the percentage of longer and shorter is much lower than for a destination more than 3km away. The majority of people choosing within 2 km are stating that the trips became longer while the majority of people selecting any distance more than 3 km are saying that it became shorter.

A multinomial logit model was calculated to predict the relationship of the change in the trip distance affected by the flyovers with different variables of the demographic data, such as age, gender, relation to Heliopolis, main mobility mode choice etc.

The model has a significance of 0.005 and includes the following variables:

Demographic Variables

- Gender
- Age
- Occupation
- Income
- Relationship to Heliopolis (resident, visitor, working in Heliopolis)

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Car and Bicycle ownership
- Main mode choice
- Frequency of using the flyovers (Fly_freq)

According to the model, several variables are significantly associated with the flyovers having affected the trip distance. The following conclusions can be made:

- Students are significantly associated with the flyovers having affected the trip distance
- Respondents using the flyovers most of the times in their trips are significantly (90% Confidence Level (CL)) associated with the effect of the flyovers on the trip distance
- All age groups from 18 – 65 years are significantly associated with the flyovers affecting the trip distance
- Respondents with an income from 0 – 9000 EGP are significantly associated with the flyovers having affected the trip distance
- The distance of the main Heliopolis destination being within 2km is significantly associated with the flyovers affecting the trip distance
- Bicycle ownership in this model has a significant association with the flyovers affecting the trip distance

Trip Duration

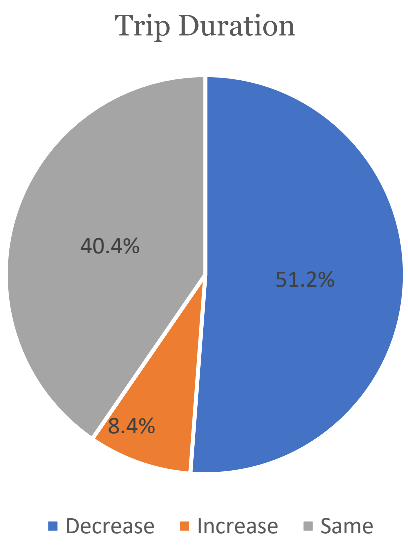


Figure 45: Change in Trip Duration (Author)

To be able to measure the change in trip duration, two questions were asked in the survey. What is the average trip duration before the flyover construction and what is the average after. With these two answers, it was possible to identify the change through three main categories, trips decreased or increased in time or stayed the same.

The majority of the answers, with 59.6%, showed a change in trip duration between both periods, while 40.4% state that the trip duration is the same. However, most people noticed a decrease of the trip duration after the flyover construction.

A multinomial logit model was calculated to examine the relationships of different variables with the change in trip duration. With a model of 0 significance, several variables were tested, such as the following:

Demographic Variables

- Gender
- Age
- Occupation
- Income

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Car and Bicycle ownership

- Main mode choice
- Frequency of using the flyovers (Fly_freq)

Based on this model, the following statements can be made:

- Respondents with an income from 3000 – 6000 EGP are significantly associated with the flyovers having affected the trip duration
- The gender is significantly associated with the flyovers affecting the change in trip duration
- The frequency of respondents using the flyovers daily is significantly associated with the flyovers having affected the trip duration
- The distance of the main Heliopolis destination of the respondents is significantly associated when more than 5km and slightly associated when within 1km with the flyovers affecting the trip duration
- The ownership of cars or bicycles is significantly associated with the trip duration being affected by the flyovers
- Age groups between 26 and 65 years are significantly associated with the trip duration change affected by the flyovers

Trip Frequency

One of the questions in the survey aimed to identify the changes in the monthly average number of trips. As it seems from the answers, for most of the people, the trip frequency did not change. This was an indicator that needed no further analysis as it was not affected by the flyovers. However, for the minority for whom the trip frequency did change, the trips became less in number.

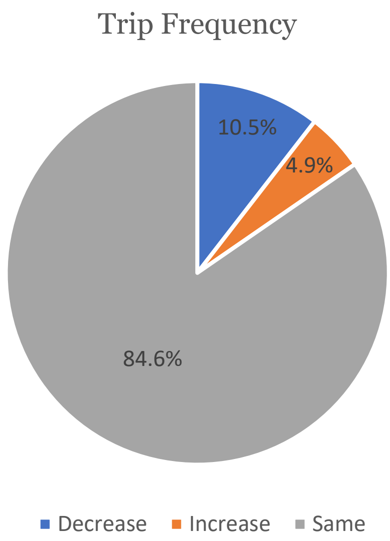


Figure 46: Change in Trip Frequency (Author)

Travel Cost

The question of the average monthly travel cost was asked twice to measure the travel cost changes between the period before and after the flyovers.

For 85% of the participants, the travel cost did not change, and for whom it did, the higher percentage was representing the decrease in the travel cost. According to these numbers, the flyovers did not have a significant effect on the travel cost, and thus this aspect was not further analyzed.

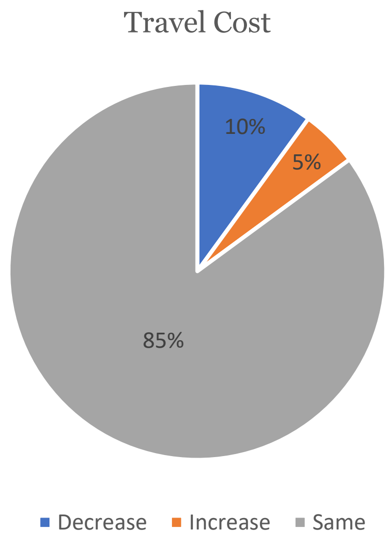


Figure 47: Change in Travel Cost (Author)

Route choice

To be able to identify the change in route choice, it was asked in the survey if the flyovers affected their route choice, followed by a qualitative question asking how. As a result, 72.4% of the respondents said that the flyovers did affect their route choice.

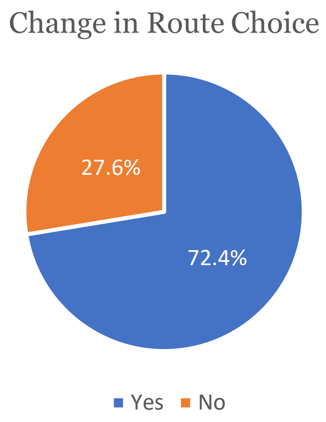


Figure 48: Change in Route Choice (Author)

A multinomial logit model, with a significance of 0, was calculated to examine which variables are associated with the effect of the flyovers on the route choice

The model included the following variables:

Demographic Variables

- Gender
- Age
- Income
- Relationship to Heliopolis (resident, visitor, working in Heliopolis)

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Car ownership
- Main mode choice
- Frequency of using the flyovers (Fly_freq)

According to the model, the following statements can be made:

- The income level more than 12000 EGP is significantly associated with the flyovers affecting the route choice, while income levels from 0 to 12000 EGP are significant with a 90% confidence level

- The distance between the flyovers and the destinations in Heliopolis, from 1km to 2km, is significantly associated with the flyovers affecting the route choice. Destinations within 1 km from the flyovers are significant with a 90% confidence level
- The age is significantly associated with the flyovers affecting the route choice
- Owning a car is significantly associated with the effect of the flyovers on the route choice

The qualitative question was asking how the flyovers affected the route choice. The main points that were mentioned are related to people choosing routes based on their preference for taking or avoiding flyovers. It also included people being misoriented, thus driving/walking more to find the way to their destinations, as well as people choosing the shortest route, they can find regardless of using flyovers or not.

Figure 49: Word Cloud created from qualitative responses about route choice (Author)

Moreover, some of them feel forced to use certain routes based on either the one-way streets or based on needing to take the flyovers or being stuck with making several U-turns to arrive at the destination. Some of the participants started to avoid either a particular mode, such as mass transit or walking or started avoiding routes that have a lot of U-turns or congestion spots. Furthermore, several respondents either aim to take the main streets to arrive at their destinations and thus usually taking some of the flyovers or try to avoid flyovers by taking shortcuts through inner streets.

Mode choice

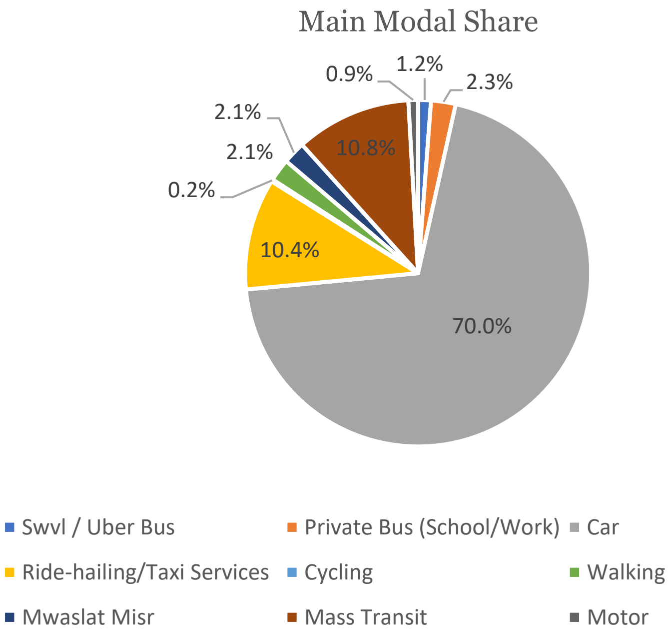


Figure 50: Main Modal share of Respondents (Autor)

When asked about the main mobility mode the respondents use in general; the result was that the majority uses private cars, with 70%, coming second is mass transit 10.8% and Ride-hailing and taxi services with 10.4%. (see chart)

Moreover, the modal share of the trips to/from/within Heliopolis were identified, through asking about the top three destinations related to Heliopolis and the mode for each destination. This question was asked twice to reflect the state of before and after the flyover construction.

In general, the modal share related to Heliopolis before the flyovers is very similar to the main modal share, except that walking increased by 2.7% and ride-hailing by 3.3%, while mass transit decreased by 3%. This change can be justified because in the main modal share, it was asked about the main mode used in general, which is very unlikely to be walking. However, for destinations within Heliopolis, walking can be a convenient mode of mobility. Also, internal trips might be more applicable with ride-hailing or taxi services than mass transit, as usually for the internal trips people seek door to door transportation.

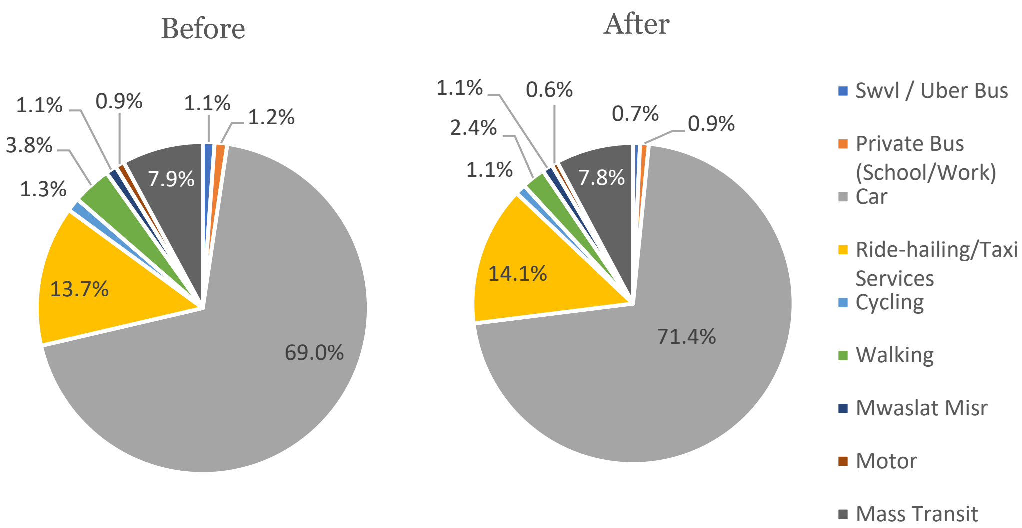


Figure 51: Modal Share of Heliopolis related Trips: Before & After the Flyovers (Author)

Comparing the modal share for Heliopolis destinations before and after the flyover construction, the differences can be seen mainly in the walking and private cars. The walking percentage decreased by 1.4%, while private cars increased by 2.4%. To be able to examine this change and to identify the modal shift for these affected trips, further analysis was conducted.

While comparing the modal share from the before and after periods, several trips were affected. These trips show a change in the mobility mode between the before and after state of the flyover construction. For most affected trips, people shifted from several modes to private cars, followed by ride-hailing/taxi services and then mass transit. As seen in Figure 53, the percentage of people changing from any other mode of transport to private cars is 43.5%.

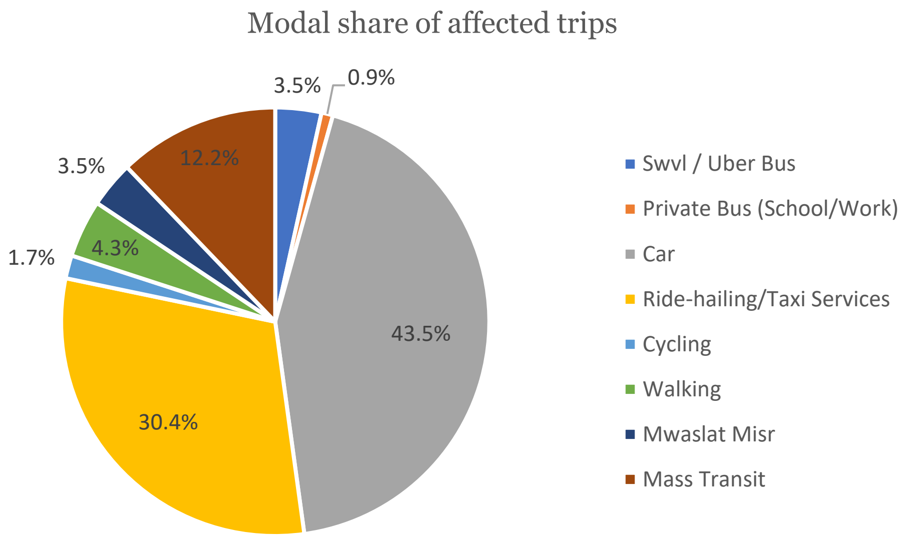


Figure 53: Modal share of Heliopolis related affected trips (Author)

People who were using non-motorized transport (NMT) as a mode for any of Heliopolis destinations and changed the mode after the flyover construction shifted to mainly using private cars, with 65%, followed by Ride-hailing/Taxi services and lastly mass transit.

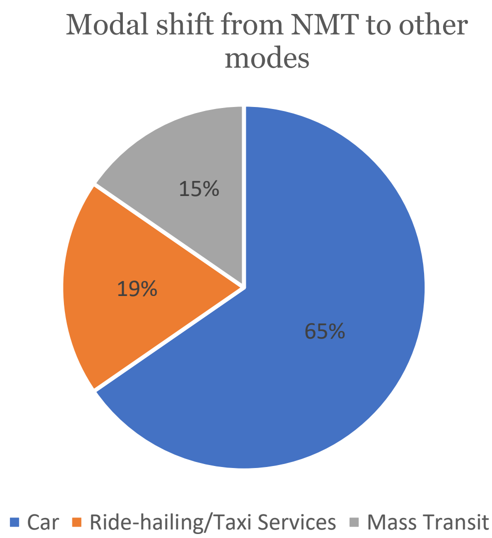


Figure 52: Modal shift from NMT to other modes (Author)

Interchanging Trips

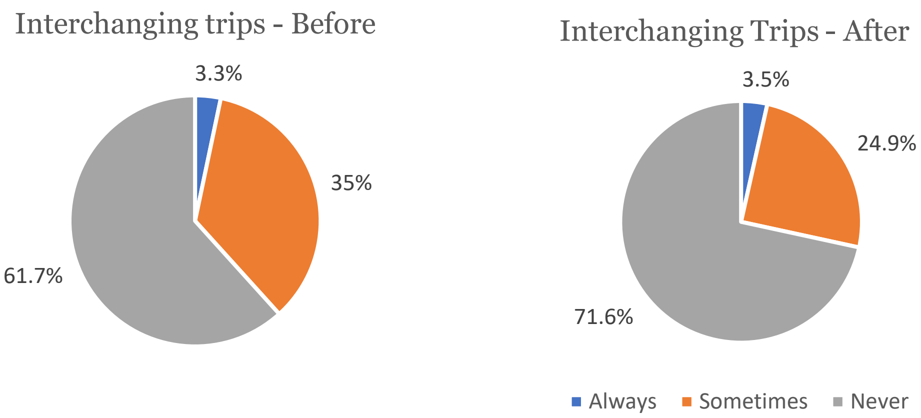


Figure 54: Interchanging Trips before & after flyovers

As an answer to the question, if they change their mode within the trip, 61.7 % of the respondents said they never do, while 35% said they sometimes do. This percentage changed a bit after the flyover construction. Now 71.6 % never change their modes within a trip, and around 25% sometimes do. The high rate of people never changing their mode within a trip in both periods could be an indicator of the majority using private cars or ride-hailing/taxi services and thus, do not need to change the mode within a trip. This percentage increased after the flyover construction, which could be an indicator of the increase in the usage of these two modes.

Affected non-motorized transport (NMT)

In the survey, a question asked about if the participants' NMT trips were affected by the flyovers. 70.6% of the respondents stated that the flyovers did affect their NMT trips. A qualitative follow up question was asked to identify how these NMT trips were affected.

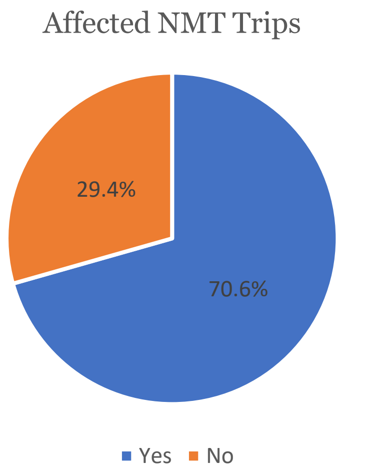


Figure 55: Affected NMT Trips (Author)

The age ranges from 26-35 years are the most affected, followed by the range of 18 to 25 years. This could be justified, as usually these age ranges are the ones who use active travel as a means of transportation more than the older generations. As for people above 65 years, all of them agreed to their NMT trips being affected. People above 65 might not always be using NMT as a mode of mobility, however, might be the most vulnerable age group that would get affected with the flyover construction due to the increased car speed and the

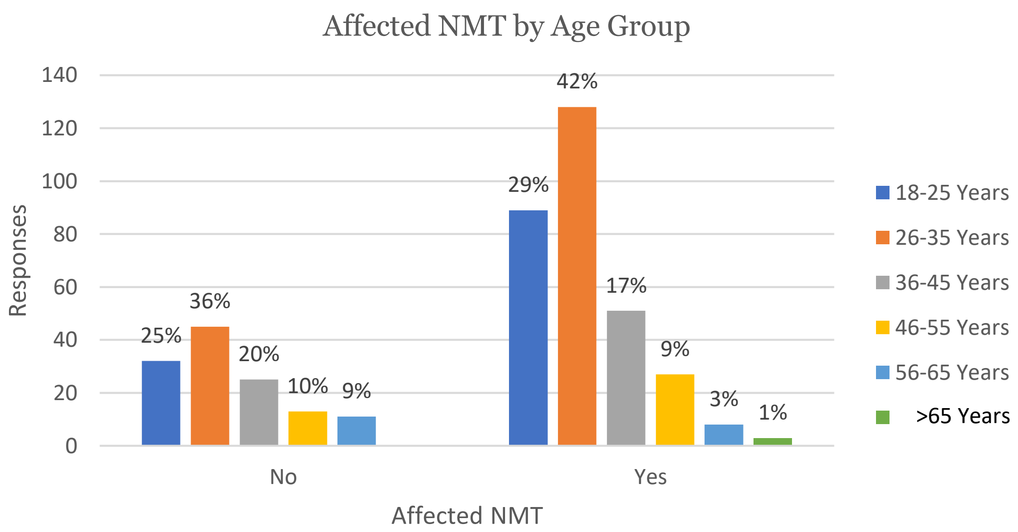


Figure 56: Chart from Pivot table: Affected NMT by Age Group (Author)

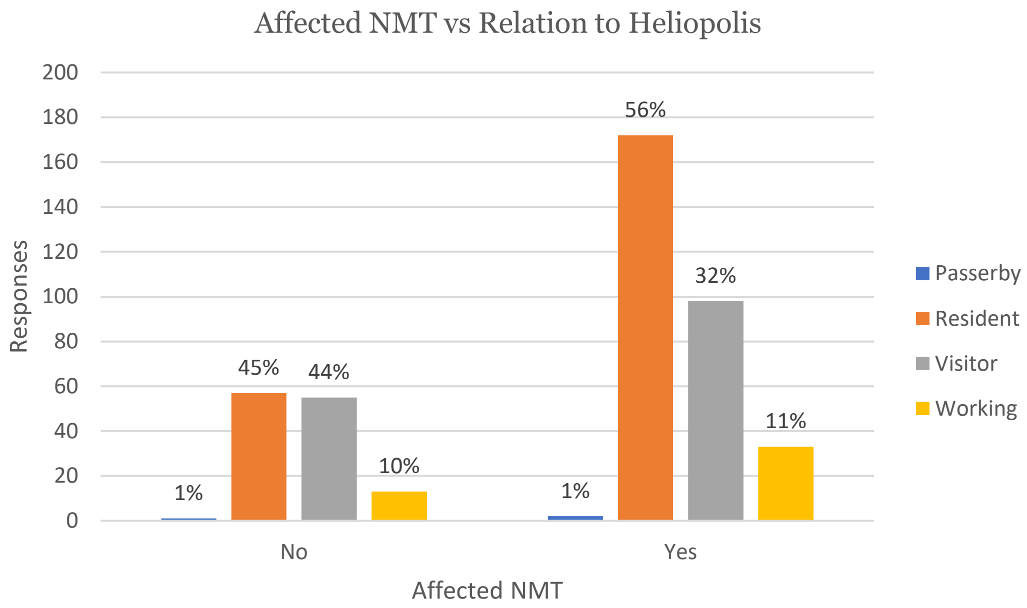


Figure 57: Chart from Pivot table: Affected NMT vs Relation to Heliopolis (Author)

In relation to the bicycle ownership, 85.3% of people owning a bike stated that the flyovers affected their NMT trips.

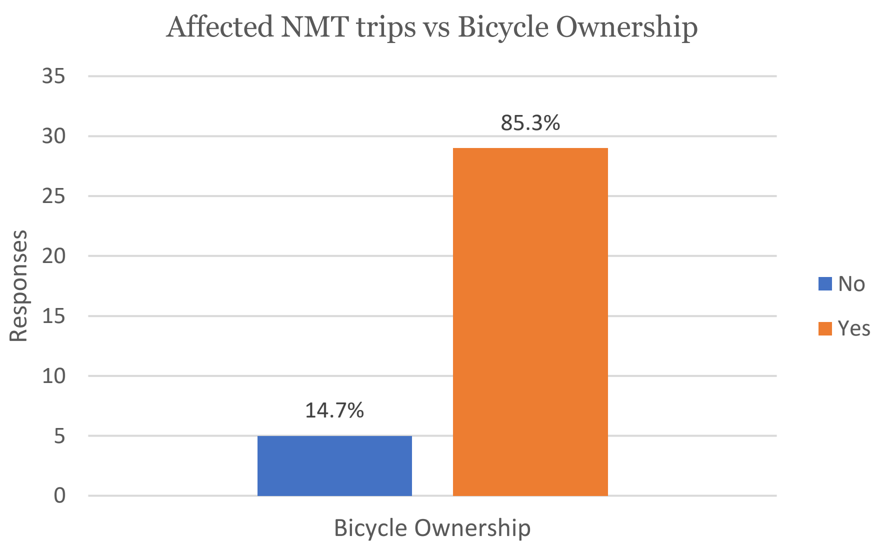


Figure 58: Chart from Pivot table: Affected NMT vs Bicycle Ownership (Author)

To further investigate the affected NMT trips, a multinomial logit model was calculated. The significance of the model is 0.5, and the overall classification percentage is 70%.

The variables included in the model are:

Demographic variables

- Age
- Relationship to Heliopolis (resident, visitor, working in Heliopolis)

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Bicycle ownership
- Frequency of using the flyovers (Fly_freq)

Based on the model the following variables are significantly associated with affecting NMT:

- The age ranges from 18 till 45 years are significantly associated with the flyovers affecting NMT trips
- Owning a bicycle is slightly significant (90% CL) when associated with the flyovers affecting the NMT trips
- The respondents' main destination in Heliopolis being within 2 km distance from the flyovers is significantly associated with the flyovers affecting NMT

The answers to the qualitative question about how the flyovers affected their NMT trips, were very diverse. However, the most common statements were regarding crossing the streets, which for some became impossible, the active travel becoming harder in general and more dangerous, as well as the increase in car speed on urban roads that were widened to become freeways. They also highlighted the lack of adequate infrastructure for pedestrians and cycling, which leads to unsafe NMT and in many cases, to accidents. Some of the most used keywords are shown in the figure below.

Figure 59: Word Cloud created from qualitative responses about affected NMT (Author)

Willingness to shift to private cars

To test the people's willingness to shift to using private cars or even buying private cars if they could afford it based on the construction of the flyovers, most people said yes.

71% of people willing to shift or use the car more often after the flyover construction already are using a car as the main transportation mode, while 63% of them already own a car. The other 29% would shift from other modes to private cars.

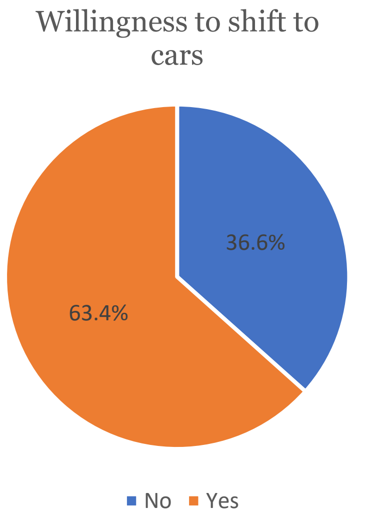


Figure 60: Willingness to shift to cars

This data can be seen as an indicator that in the future the private cars will increase, as well as the traffic flow, leading to potential traffic congestions once again. This phenomenon supports the concept of induced traffic, mentioned in Chapter 2.

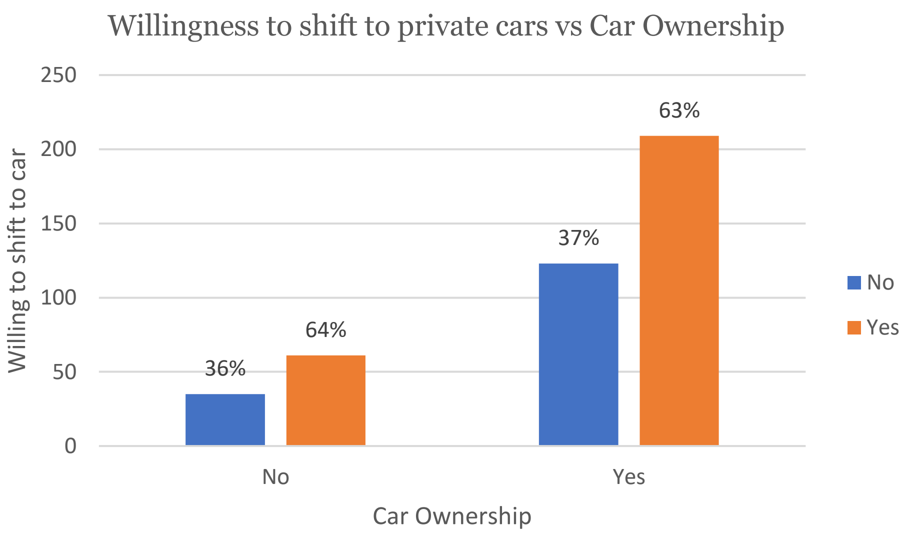


Figure 61: Chart from Pivot table: Respondents willingness to shift to private cars vs car ownership (Author)

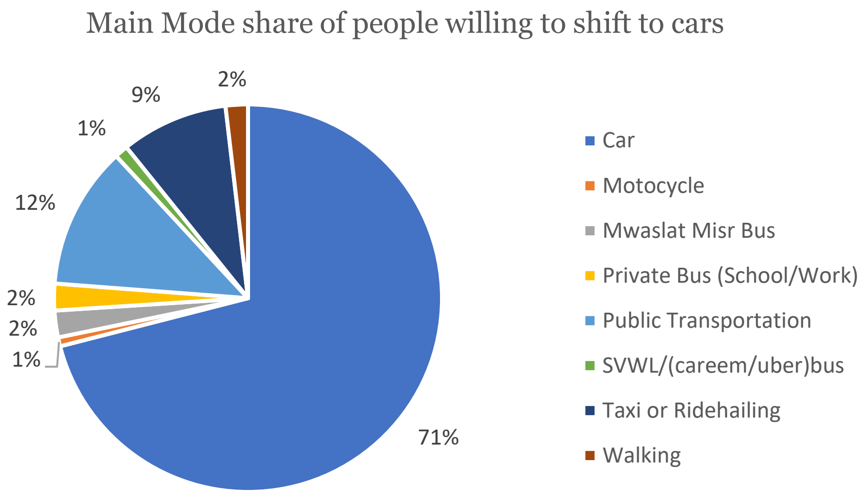


Figure 62: Main modal share of people willing to shift to private cars (Author)

Connectivity

In the survey, one of the questions was tackling the change in connectivity from the before and after state. It was a multiple-choice question with four answer options (See Figure 63). Based on the survey, the connectivity changed for the majority. The most significant percentage of people who faced a change is now connected to the same destinations; however, reaches them faster now.

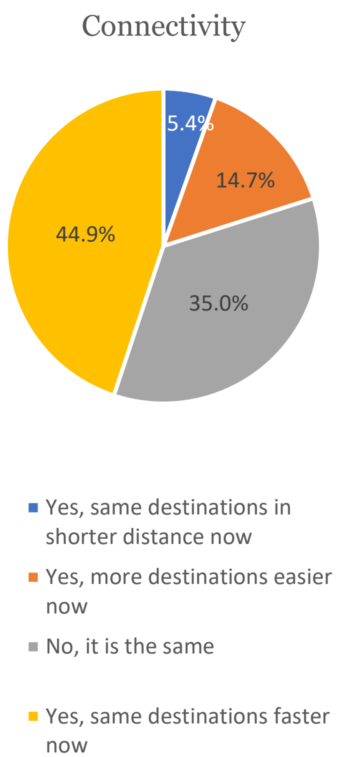


Figure 63: Change in Connectivity (Author)

For most residents, the connectivity changed. Now they can reach the same destinations as before but faster. For the visitors, the most common answer is that the connectivity either stayed the same or reaching the same destinations became faster. However, for almost all respondents, neither the distance became shorter nor more places are being accessible that were not before.

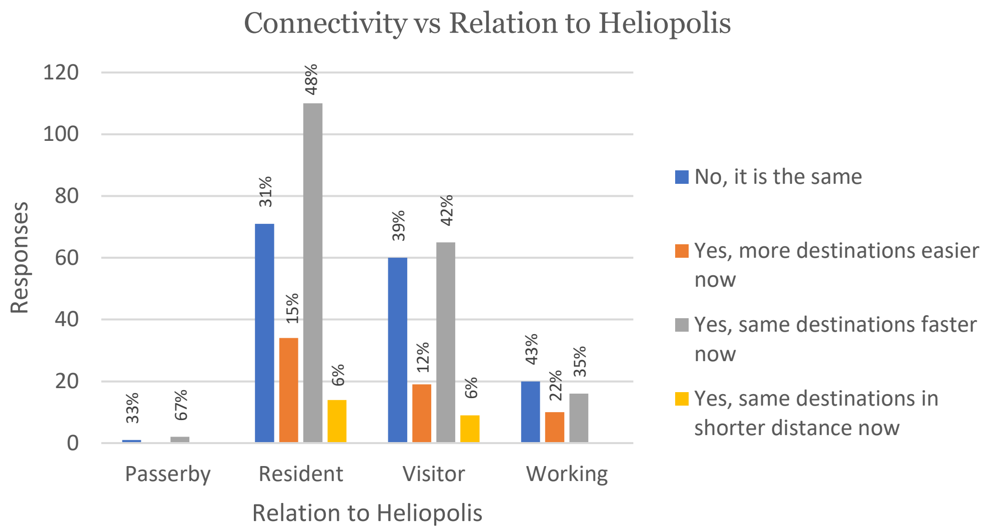


Figure 64: Chart from Pivot table: Connectivity vs Relation to Heliopolis (Author)

It is visible through the chart above that the frequency of using the flyovers are somehow associated with the connectivity changing. For people using the flyovers daily, 71% of them experienced a change in connectivity. For people using the flyovers rarely, the majority did not experience any change in their connectivity.

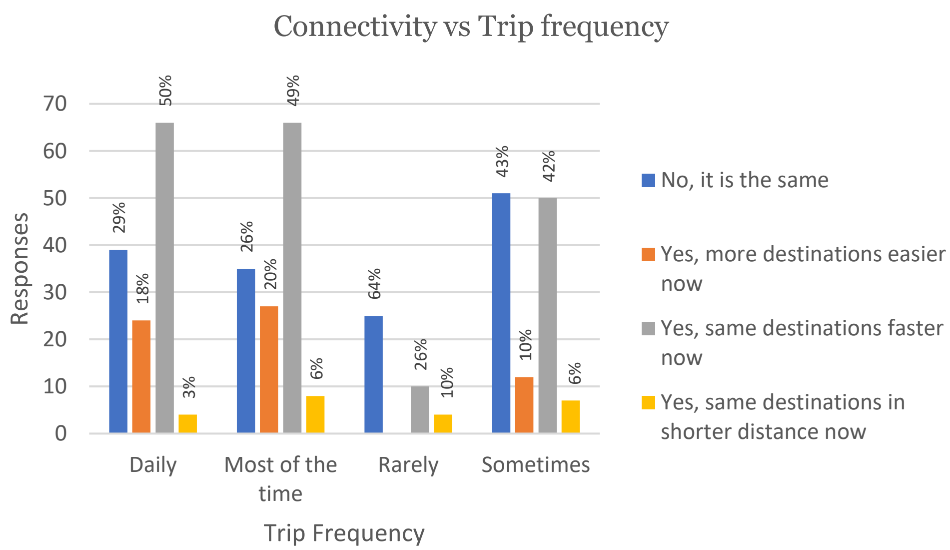


Figure 65: Chart from Pivot table: Connectivity vs Trip frequency (Author)

This relation between the connectivity and the frequency of using the flyovers is supported by the results of the following multinomial logit model. The significance of the calculated model is 0.0.

The model includes the following variables:

Demographic Variables

- Gender
- Age
- Income

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Main mode choice
- Frequency of using the flyovers (Fly_freq)

The relation between the connectivity and some of the variables are significantly associated with the flyovers influencing the connectivity. These variables are as follows:

- The frequency of using the flyovers is significantly associated with the flyovers affecting the connectivity of the respondents
- The gender is a significant variable associated with the effect of the flyovers on the connectivity
- The distance of the main destination in Heliopolis to the flyovers within 1 km and more than 5 km is significantly associated with the effect of the flyovers on the connectivity. The distance of 1 - 2km is significantly associated with a 90% confidence level.
- The age is significantly associated (90% CL) with the connectivity being affected by the flyovers
- Income levels from 0-9000 EGP are significantly associated with the flyovers affecting the connectivity

Trips affected by the flyovers

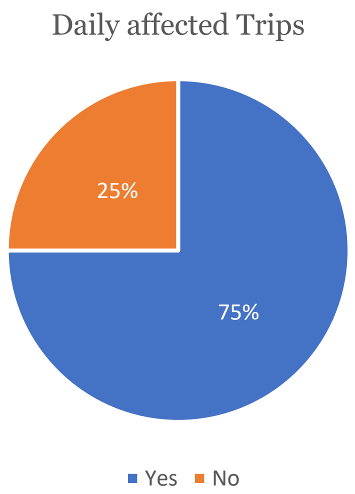


Figure 66: Daily affected trips (Author)

When asked if the flyovers affected their daily trips, most of the respondents (75%) said yes. A qualitative follow-up question was asked to understand how exactly the flyovers affected their daily trips.

Because the residents of Heliopolis are the people interacting with the flyovers the most and the ones that need to deal with all its effects most of the time, 59% of the respondents affected by the flyovers are residents. These represent 83% of the residents who took the survey. The second affected group of people are the visitors.

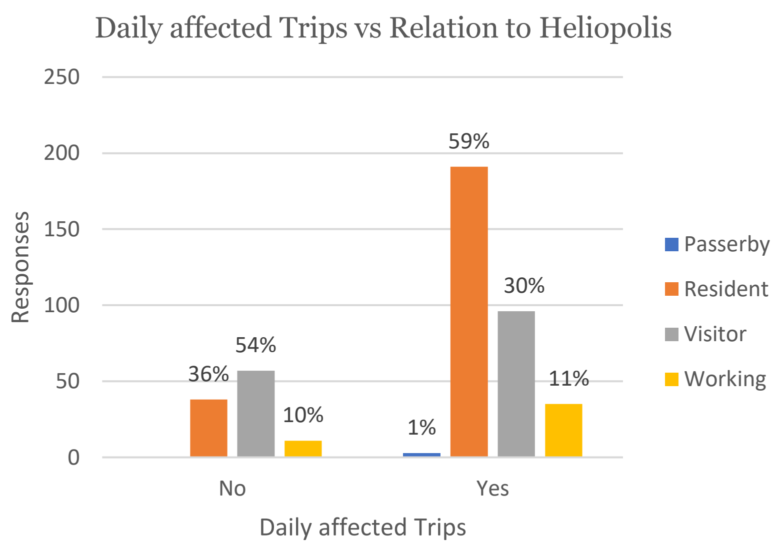


Figure 67: Chart from Pivot table: Daily affected trips vs Relation to Heliopolis (Author)

A relation between the frequency of using the flyovers and the daily trips being affected is clear through the following bar chart. The majority of affected daily trips come from people using the flyovers daily or most of the time, followed by people using them sometimes. This correlation is also supported by the multinomial logit model calculated to analyze the daily trips being affected.

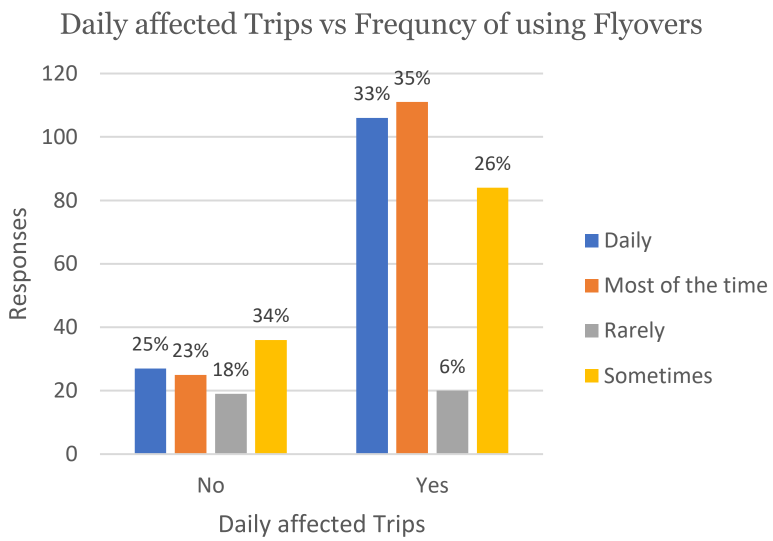


Figure 68: Chart from Pivot table: Daily affected trips vs Frequency of using the flyovers (Author)

To identify the variables that are associated with the daily trips that got affected by the flyovers, a multinomial logit model was calculated. The model has a significance of 0.003 and a classification percentage of 77.6%.

The independent variables that are included in the model are as follows:

Demographic Variables

- Gender
- Age
- Income
- Relationship to Heliopolis (resident, visitor, working in Heliopolis)

Personal Mobility Data Variables

- Distance of the main Heliopolis destination to the flyovers (Fly_distance)
- Car and Bicycle ownership
- Main mode choice
- Frequency of using the flyovers (Fly_freq)

Based on the model the following variables are significantly associated with the daily trips being affected:

- The frequency of using the flyovers is significantly associated with the daily trips being affected by the flyovers
- The main mode choice is significantly associated with the daily trips affected by the flyovers
- The age group from 55 to 65 years is slightly significant (90% CL) when associated with the daily trips being affected by the flyovers.

According to the qualitative data gathered as a follow-up to this question, it is obvious that for a lot of people, the daily trips became faster, with no congestion. This is also underlined by the results of the trip duration analysis discussed earlier. Other common statements were regarding the length of the trips; a lot of respondents mentioned that the trips became longer. While some stated that they are taking more time due to the extra distance, some of them mentioned that they became shorter and easier. According to the trip distance analysis discussed before, only around 35% stated that the trips increased in the distance, and 45% stated that it decreased.

In addition, people highlighted the issue of parking spaces that have been eliminated due to the widening of the streets and the space the flyover takes up from the streets. Residents and visitors perceive it harder now to find a parking spot. Another concern was the number of U-turns that need to be taken to arrive at a particular destination. Instead of being able to reach a place through a direct way, now many people need to go through several U-turns to arrive.

Moreover, several people mentioned the issue of active travel, especially pedestrian crossings, which became dangerous, causing several accidents. Other keywords that were mentioned are represented in the word cloud below.

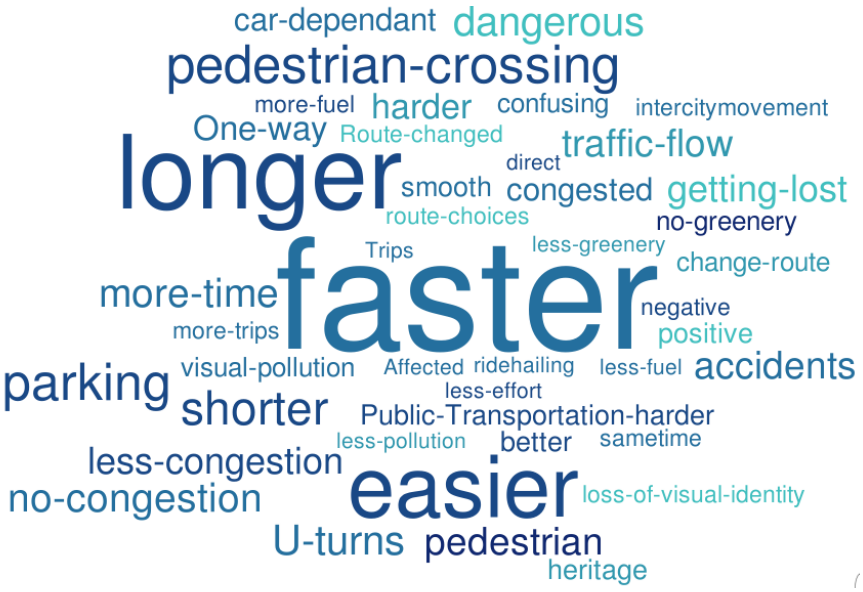


Figure 69: Word Cloud created from qualitative data about the daily affected trips (Author)

Flyover Satisfaction

At the end of the survey, the participants got a chance to briefly express some of their opinions regarding their satisfaction with the flyovers. They were asked about the advantages and disadvantages of the flyovers. In addition, they were asked their suggestion for several alternative traffic solutions that might have been more fitting in their opinion. Each participant could choose several answers per question while also being able to add more options to the list of answers if needed.

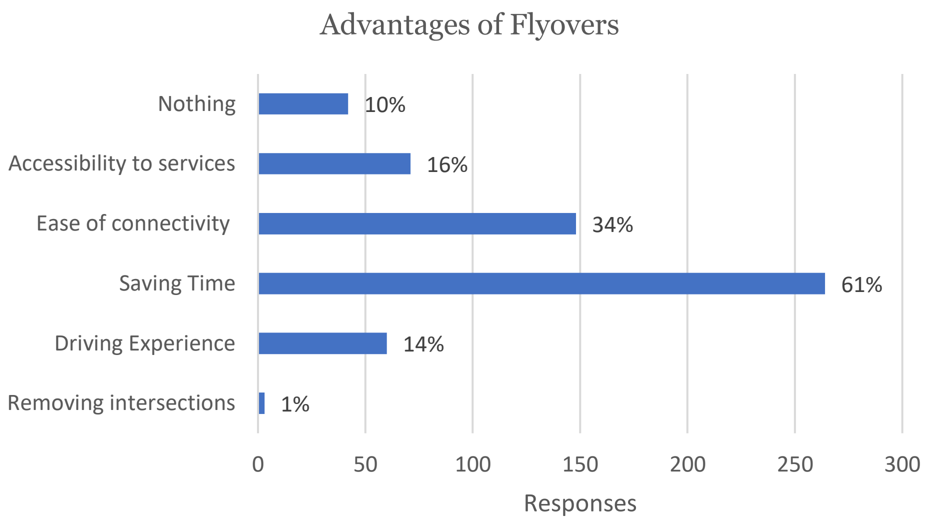


Figure 70: Heliopolis Flyovers Advantages (Authors)

The majority stated that the flyovers are saving time while commuting. This statement appeared several times throughout the previous analysis as well. Coming second is the ease of connectivity, which was also analyzed in-depth before in the connectivity aspect part. However, 10% of the responses stated that they could not see any advantages to the flyovers.

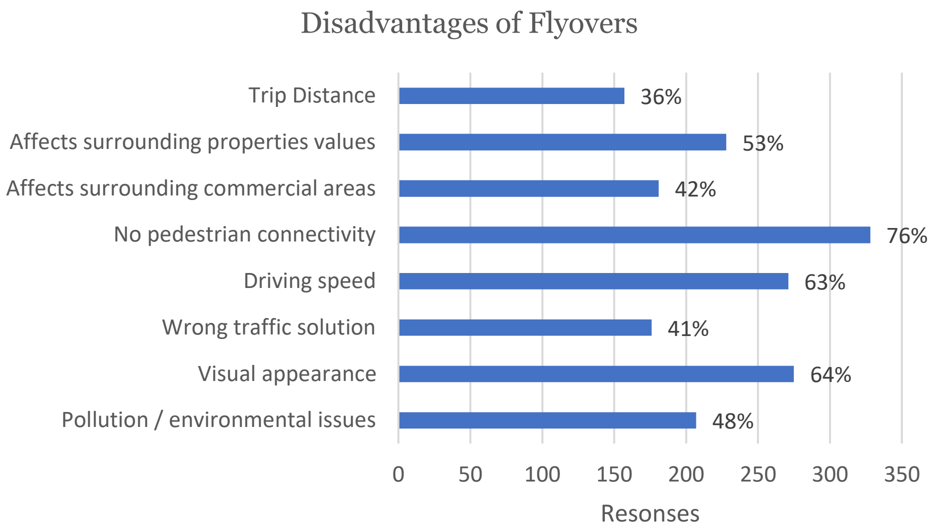


Figure 71: Heliopolis Flyovers Disadvantages (Author)

The main disadvantage that appeared in the responses was the lack of pedestrian connectivity. This was also a big concern that was mentioned throughout several responses to several questions in the previously analyzed aspects. The driving speed and visual appearance followed next with a percentage of 63-64 %. In addition, more than half of the responses suggest that the flyovers affected the property values of the surrounding buildings. Moreover, around 41% of the responses state that the flyovers are not the right solution for the traffic problem, which can be supported by the answers of the following question.

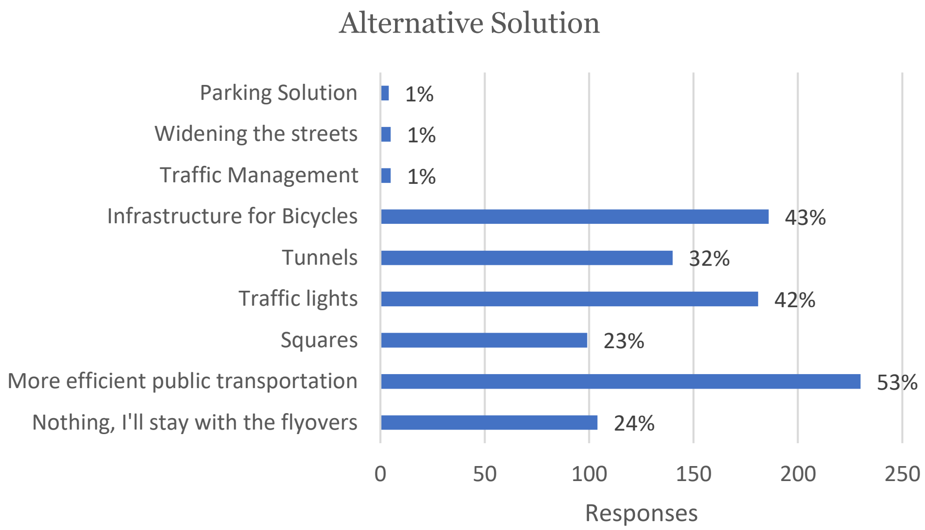


Figure 72: Alternative traffic solutions for Heliopolis flyovers (Author)

When asked about a potential alternative traffic solution rather than the flyovers, most of the people chose more efficient public transportation. Infrastructures for bicycles and traffic lights were the second most selected responses. Nonetheless, 24% of the responses support the flyovers and would stay with this traffic solution.

Through the several analysis, qualitative and quantitative, it is evident that the flyovers did have an effect on the travel behavior of people living, working or simply visiting Heliopolis. Some of these effects are positive, enabling a decreased trip duration and a shorter trip distance, making connectivity easier. Others are rather negative affecting their daily life through being not able to safely cross the streets or access places like they are used to, affecting their route or mode choice. However, there are also aspects that were not affected by the flyovers, such as trip cost and frequency.

Moreover, the analysis showed that the flyovers might change the travel behavior of the people in the long run, encouraging them to use private cars more often or even buy them. This change in behavior might result in traffic changes that would affect the macroscale travel patterns as well.

Conclusion

Based on the macroscale analysis, it is visible that there was a change in traffic congestion and flow, especially in Heliopolis, between before and after the flyover construction. The congestion shifted from Heliopolis to its surrounding areas, increasing the travel speed within the Heliopolis district. Several corridors linking the district with other areas within Greater Cairo Region showed changes in congestion level as well. Moreover, the peak hours slightly changed, either by being mitigated or by changing the time of day.

This travel change on the macroscale is also reflected on the microscale. Through the analysis, it is evident that the flyovers affect the travel behavior of people living, working or visiting Heliopolis. Similar to the macroscale, the microscale analysis shows that the flyovers affected the trip duration, decreasing the travel time. Other positive effects include shorter trip distance and making the connectivity easier. Nonetheless, the flyovers showed negative effects on people’s daily life by affecting their active travel, making it more dangerous or by making the accessibility for some areas harder, thus affecting their route or mode choice.

In the analysis, some possible future trends, such as induced traffic, were discovered through the data about the respondents' willingness to shift to private cars after the flyover construction. The change towards cars is already seen in some of the data collected by the survey. The modal share between before and after the flyovers slightly shifted towards private cars. Also based on the qualitative analysis, several respondents highlighted that they replaced most NMT trips with private car trips after the construction of the flyovers. This change in behavior might result in traffic changes affecting the macroscale travel behavior in the future.

9. Chapter 9: Discussion and Conclusion

In this chapter, the results of the analysis are being discussed, highlighting several relations and links throughout the whole research, arriving at several conclusions and future recommendations for similar studies in this field.

9.1. Discussion

The traffic development project in Heliopolis got introduced to facilitate traffic inside the Heliopolis neighborhood and link it to the main axes extending to the neighboring urban communities and new cities, as well as to inner Cairo. Heliopolis was the first district in Cairo to undergo such development due to its unique location acting as a link and entrance between the East and West of Cairo. According to a traffic analysis presented in the book "Heliopolis- City in a City", only 5.5% of the traffic goes from Heliopolis to the city center, and 4% goes from the city center to Heliopolis. However, 30% of the traffic pass by Heliopolis to reach the city center or the new desert cities, in addition to the people coming and going to the airport (Herzog et al., 2010).

Based on the anticipated increase of traffic demand potentially generated by the New Urban Communities, especially the New Administrative Captial, Heliopolis became a priority in accommodating the expected growth of capacity before resulting in more critical traffic issues (Okeil, 2020b). With the new project, the travelers will be directed through the Ring Road, not needing to enter Heliopolis, to go from East to West of Cairo or vice versa (Okeil, 2020c). This exact aim was one of the main reasons mentioned by the urban planners in the past, during the thirties and nineties. In their opinion, the highway system would revitalize the urban cores by reducing the traffic within the city streets through channeling the cars and vehicles outside of the downtown areas (Bauman, 1991; Mackaye and Mumford, 1931).

According to the macroscale analysis, there was a change in traffic congestion and flow between before and after the flyover construction. The congestion shifted from Heliopolis to its surrounding areas, increasing the travel speed within the Heliopolis district. This shift of traffic from areas that underwent an increase in road capacity to surrounding areas was mentioned in the literature through cases such as the Suez Road. After the expansion of the Suez Road, a bottleneck situation was created at the entrance of Heliopolis causing increased traffic, eventually leading to the initiation of the traffic development project in Heliopolis (The SUbMonitor, 2020).

The affected areas to which the traffic shifted are to the North, such as Sheraton, to the North-West, such as Ain Shams, Al Zaytoun, Al Amiryah, as well as to the South, like Nasr City. Similar to what happened in Heliopolis after the expansion of the Suez Road, some of the affected areas are either undergoing or already underwent similar traffic development projects, eliminating the congestion shifted towards them after the completion of the Heliopolis project. Eight flyovers are already constructed in areas surrounding Heliopolis (Sabry, 2020). The construction of these new flyovers in the neighboring areas of Heliopolis ended in May 2020 (Sabry, 2020), which is before the data collection of this research and thus are reflected in the analysis. Yet, according to the analysis, the congestion is still present in those areas. This might open the discussion on what will happen to the traffic shifted from these areas to the areas surrounding them.

In addition to the surrounding areas, main corridors linking to several parts of Cairo showed changes in their congestion level, such as the beginning of the Suez Road, which eventually connects to the New Urban Communities. The decrease in congestion level on the Suez Road was one of the aims of the traffic development project in Heliopolis, as a way to mitigate the bottleneck at the meeting point of the Suez Road and Heliopolis (The SUbMonitor, 2020).

According to the visualization analysis and the analyzed numbers, the most affected peak period showing a change from before and after the flyover construction is the evening peak, which is the most congested period of the day. Generally, the congestion level between the peak periods before and after the construction of the flyovers are decreased. In addition, the peak hours slightly changed, either by being mitigated or by changing the time of day. This congestion relief might be temporary, followed by induced traffic in the future, as discussed in several international (Cervero, 2003; Choi et al., 2014; Duranton and Turner, 2011), as well as local literature (El-Dorghamy, 2020a a; Hegazy, 2020; The SUbMonitor, 2020).

The shift of congestion from Heliopolis and thus, the increased travel speed in the area, is also reflected in the microscale analysis results. Through the several qualitative and quantitative analysis, it is evident that the flyovers did influence the travel behavior of people living, working or simply visiting Heliopolis. Some of these effects are positive, enabling a decreased trip duration, as seen in the macroscale analysis as well. Further positive effects include shorter trip distances and making connectivity to destinations smoother and easier, as also stated by Dr. Ossama Okeil, the transportation planner and engineer of the Heliopolis project (Okeil, 2020c). Other effects are rather negative, affecting their daily life through not being able to safely cross the streets or access places like they were used to, as well as affecting their route or mode choice. However, there are also aspects that were not affected by the flyovers, such as trip cost and frequency.

Moreover, the analysis showed that the flyovers might change the travel behavior of the people in the long run, through changing their modal choice to private cars. The results show that the majority of the respondents are willing to use private cars more often or even buy a car if they do not own one after the flyover construction. This change in behavior after the increase in road capacity is mentioned several times by international and local literature (Cervero, 2003; Choi et al., 2014; El-Dorghamy, 2020a; Hegazy, 2020). The change in modal choice is already apparent in some parts of the data collected by the survey. The change in modal share between before and after the flyovers is mainly moving towards private cars. Also based on the qualitative analysis, several respondents highlighted that they replaced most NMT trips with private car trips after the construction of the flyovers. This is an indicator that supports the concept of induced traffic that might appear in the future in Heliopolis or its surrounding areas.

Limitations

As mentioned in the scope and limitation part, the pandemic of COVID-19 is one of the main limitations of this research. The pandemic affected the approach and methodology of the research on the macro and microscale. A common limitation affecting both scales is in the data collection phase. Data gathered after the beginning of pandemic represents a specific state, due to the change in travel behavior during the pandemic on the macro and microscale. To mitigate this on the microscale, the data collection was specific to the period before the pandemic. However, the period between the end of ETI construction and the beginning of the pandemic is roughly two months, which might be a bit short of identifying certain travel behavior changes. As for the macroscale, this mitigation was not possible due to the nature of the analysis tool. Thus, the data during the pandemic period was included in the analysis.

Another effect of the pandemic was the inability to conduct any fieldwork. This affected mainly the microscale analysis. The survey being online, led to the underrepresentation of certain demographic groups, such as age and income class groups that do not have access to the internet. Also, the researcher was unable to assure a balanced demographic representation reflecting the reality of the study area, of aspects like gender distribution. In online surveys, it is hard to choose certain demographic groups to balance the distribution. In addition, several qualitative data could have been gathered through observing the travel behavior of people near the flyovers. These data would have been beneficial to understand the behavior of the people more in-depth.

Another limitation was due to the methodology used on the macroscale. Due to the limited timeframe of the research, the analysis needed to get conducted before having complete data on the selected ETIs. The limitation of using FCD from Google Transit in this research is that the flyovers have been constructed recently. Thus, the street network projected on Google Maps was not fully updated with these new infrastructures. By the time of the data collection, only two flyovers out of five were updated on Google Maps. This might have led to some inaccuracies in the data, especially for the data on streets with the flyovers. However, the effects of those flyovers on the rest of the street network are accurately represented in the analysis. Thus, the objective of examining the effects of these flyovers on the road network is still fulfilled.

9.2. Conclusion

Through the various layers of analysis, it is evident that elevated transportation infrastructures have several effects on urban travel behavior on the macro and microscale. Some of these effects were mentioned in international literature, some in local resources, and some might be case-specific and only occurred in the case study of this research. The research's objectives were to examine the effects of the ETIs on two scales through examining different aspects in each scale. A comparison between the results of both scales was not part of the research objectives. However, when looking at the result of both analysis, some reoccurring insights appeared, enriching the results the research.

In general, local literature or empirical studies on the effects of ETI on the urban environment are lacking. However, the limited sources discuss the effects on the different dimensions of the urban environment, including social, environmental, and economic aspects. Some of the sources tackle the effects of the ETIs on the traffic situation on the macroscale. However, discussions on the effects of the ETIs on the travel behavior of people lack in the local context. Thus, one of the main objectives of this research was to examine these effects and introduce these results on the microscale and on this specific aspect.

Identifying and examining the change in traffic congestion and flow, between before and after the flyover construction was one of the main outputs of the research. The results show that the congestion shifted from Heliopolis to its surrounding areas, decreasing the traffic within the Heliopolis district. In addition to the surrounding areas, main corridors linking to several parts of Cairo showed changes in their congestion level, such as the Suez Road, which eventually links to the New Urban Communities and Salah Salem Road linking to inner Cairo.

According to the macroscale analysis, the most congested period of the day is the most affected peak period showing a change from before and after the flyover construction, which is the evening peak. Generally, when comparing the effects on the congestion level of the peak periods before and after the construction of the flyovers, it is clear that it decreased.

Through the analysis on the microscale, it is evident that the flyovers affect the travel behavior of people using the flyovers in Heliopolis. Same as the macroscale, the microscale analysis shows that the flyovers affected the trip duration by decreasing the travel time. Other positive effects include shorter trip distance and making the connectivity easier. Nonetheless, the flyovers showed negative effects on people's daily life by making the accessibility for some areas harder, thus affecting their route or mode choice and by affecting their active travel, making it more dangerous.

Some possible future trends, such as induced traffic, were discovered through the data about the respondents' willingness to shift to private cars after the flyover construction. This can be already seen in modal share comparing before and after the flyovers. There is a slight shift towards private cars, which got also supported by the qualitative analysis showing that people already replaced walking with driving. This change in travel behavior might result in traffic changes affecting the city as a whole in travel the future.

9.3. Future Recommendation

Scope of research
In this research, the scope of work was narrowed down to fit in the expected timeframe. However, for future research, I recommend expanding the scope or shedding light on other aspects that were not included in this research. The scope of this research was limited to elevated road infrastructure, flyovers. Future studies can examine other elevated transportation infrastructures such as elevated metro lines for example, especially as several elevated metro lines are being introduced to Cairo in the current times. It might also be interesting to compare the effects of different ETIs, such as flyovers with elevated metro structures. The effects analyzed in this study were limited to the effects on one aspect of the urban environment, the urban travel behavior, future research can investigate other aspects, maybe also compare these effects with one another.

Case study

Only one case study, and specific flyovers, were examined in this research. Other case studies can be considered, as well as several flyovers in several case study areas can be compared. This will show if the effects of the ETIs are case-specific or can be generalized. Also, while choosing the case study, one can vary between different urban fabric and social class neighborhoods as well as different timeframes in which the flyovers were constructed. The change in social class or urban fabric might play a role in the effects, so might the operation duration of the flyovers.

Output

The main objective of this research was to examine the effects without evaluating these effects. For future research evaluation of the ETI effects on the macro and microscale might be very interesting and beneficial in future decision making and planning processes. Also, proposing alternative solutions that might be more fitting in the specific case studies would be a good addition to this field.

Macroscale Methodology

Based on the limitations mentioned above, I recommend redoing the same methodology of the FCD collection after all of the flyovers are updated on Google maps and after the pandemic is over to get the full data and compare the results. This will enable the travel behavior to take its regular shape after the pandemic period.

I also recommend using the numerical data collected through the FCD approach in doing more quantitative and statistical analysis and compare them with the results of the visualization analysis, to get a rounded overview of the situation.

Microscale Methodology

On the microscale, I suggest including more qualitative data, such as observation of the travel behavior of people near the flyovers. Other tools such as interviews with the flyover users and cognitive mapping exercises could be included as well.

10. References

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11. Appendices

11.1. Appendix A: Travel Behavior Survey

Demographics
السن
النوع
الحالة الوظيفية
مستوي الدخل
Relation to Heliopolis
ما هى علاقتك بمصر الجديدة؟
كم يبعد منزلك / عملك / مدرستك او جامعتك / الخ.. عن الكبارى التي تم إنشاؤها فى مصر الجديدة حديثًا؟
كم مرة تستخدم هذه الكبارى في الشهر؟
Personal Mobility Data
هل تملك أيا من التالي؟ سيارة دراجة نارية حساب على برنامج حجز سيارات الأجرة(uber/careem/swvl) بطاقة اشتراك للمترو أو مواصلات مصر دراجة لا شيء مما سبق
ما هي وسيلة النقل الرئيسية التى تستخدمها؟
ما هو نوع اكثر3 رحلات رئيسية من/الي/داخل مصر الجديدة لك في الشهر؟ (اسحب إلى اليسار لعرض باقي الخيار
ما هو نوع اكثر3 رحلات رئيسية من/الي/داخل مصر الجديدة لك في الشهر؟ (اسحب إلى اليسار لعرض باقي الخيار
ما هو نوع اكثر3 رحلات رئيسية من/الي/داخل مصر الجديدة لك في الشهر؟ (اسحب إلى اليسار لعرض باقي الخيار
ما هو طول كل رحلة (اتجاه واحد)؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 1]
ما هو طول كل رحلة (اتجاه واحد)؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 2]
ما هو طول كل رحلة (اتجاه واحد)؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 3]

Table 7: Travel Behavior Questionnaire part 1 (Author)

Travel Behavior Before Flyovers
ما هي وسيلة النقل الرئيسية التي استخدمتها لكل رحلة؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 1]
ما هي وسيلة النقل الرئيسية التي استخدمتها لكل رحلة؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 2]
ما هي وسيلة النقل الرئيسية التي استخدمتها لكل رحلة؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 3]
هل تغير وسيلة النقل خلال الرحلة؟
كم عدد الرحلات التي كنت تقوم بها من / إلى / داخل مصر الجديدة؟ (الرحلة ذهاب وعودة)
كم كان متوسط وقت الرحلة من / إلى / داخل مصر الجديدة شهريا؟(الرحلة: ذهاب وعودة)
كم من المال تنفق في المتوسط على التنقل شهريًا؟
Travel behavior After Flyovers
ما وسيلة النقل الرئيسية التي تستخدمها الآن بعد بناء الكبارى؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 1
ما وسيلة النقل الرئيسية التي تستخدمها الآن بعد بناء الكبارى؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 2
ما وسيلة النقل الرئيسية التي تستخدمها الآن بعد بناء الكبارى؟ (اسحب إلى اليسار لعرض باقي الخيارات) [الرحلة 3
هل تغير وسيلة النقل في الرحلة الواحدة الآن بعد بناء الكبارى؟
كم عدد الرحلات التي تقوم بها الآن بعد بناء الكبارى؟ (الرحلة: ذهاب وعودة)
كم متوسط وقت الرحلة الآن بعد بناء الكبارى؟
كم من المال تنفق الآن بعد بناء الكبارى؟
هل تغير طول الرحلات بعد بناء الكبارى؟
هل غيّرت الكبارى اتصالك بالاماكن التى تذهب اليها؟
هل أثر بناء الكبارى على أي من رحلاتك اليومية؟
كيف؟
هل أثر بناء الكبارى على رحلات النقل غير الآلية (المشى او ركوب العجل) ؟
كيف؟
هل اثرت الكبارى على اختيارك للطريق؟
كيف؟
هل أنت أكثر تشجيعًا لاستخدام سيارتك أو شراء سيارة بعد بناء الكبارى؟
بشكل افتراضي ، إذا قللت الكبارى من وقت التنقل ، فماذا ستفعل فى الوقت الذى توفر لديك؟
Flyover satisfaction
ما الذي يعجبك أكثر في الكبارى؟
ما الذي لا يعجبك أكثر في الكبارى؟
ما هو حل المرور البديل الذي كان يمكن ان تقترحه لمساعدتك على التنقل بسهولة بدلاً من الكباري التي تم إنشاؤها

Table 8: Travel Behavior Questionnaire part 2 (Author)

11.2. Appendix B: Multinomial Logit Models

Trip Distance

Case Processing Summary

		N	Marginal Percentage
Trip_distance	Longer	147	34.3%
	Same	87	20.3%
	Shorter	194	45.3%
Valid		428	100.0%
Missing		0	
Total		428	
Subpopulation		372[a]	

a. The dependent variable has only one value observed in 343 (92.2%) subpopulations.

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	842.761			
Final	748.375	94.385	62	.005

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	729.283	680	.093
Deviance	703.216	680	.261

Pseudo R-Square

Cox and Snell	.198
Nagelkerke	.226
McFadden	.105

Likelihood Ratio Tests

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
Intercept	752.846	4.470	2	.107
Occup_employee	750.744	2.369	2	.306
Occup_Student	754.029	5.653	2	.059
Occup_not_look	751.756	3.381	2	.184
Helio_resident	748.883	.508	2	.776
Helio_working	749.035	.660	2	.719
Helio_Visitor	748.771	.396	2	.821
Fly_Freq_most	752.878	4.503	2	.105
Fly_Freq_some	749.428	1.053	2	.591
Fly_Freq_daily	750.739	2.364	2	.307
Age_18_25	758.106	9.730	2	.008
Age_26_35	759.460	11.085	2	.004
Age_36_45	758.625	10.250	2	.006
Age_46_55	755.085	6.710	2	.035
Age_55_65	757.113	8.738	2	.013
Income_0_6k	755.246	6.871	2	.032
Income_6k_9k	760.060	11.685	2	.003
Income_9k_12k	749.277	.902	2	.637
Fly_distance_1km	751.607	3.232	2	.199
Fly_distance_1_2km	754.895	6.520	2	.038
Fly_distance_more5km	750.870	2.495	2	.287
Car_yes	751.328	2.952	2	.229
Bike_yes	760.284	11.908	2	.003
Gender_Female	751.110	2.735	2	.255
Main_Mode_Car	750.218	1.843	2	.398
Main_Mode_taxi	749.372	.996	2	.608
Main_Mode_walking	750.117	1.742	2	.418
Main_Mode_priv_bus	749.299	.924	2	.630
Main_Mode_MM	750.198	1.823	2	.402
Main_Mode_PT	749.430	1.055	2	.590
Main_Mode_POBus	750.903	2.528	2	.282
Main_Mode_Motor	749.039	.664	2	.718

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Parameter Estimates

Trip_distance[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Longer	Intercept	37.195	6973.370	.000	1	.996			
	Occup_employee	-1.138	.821	1.919	1	.166	.320	.064	1.603
	Occup_Student	-2.033	.953	4.554	1	.033	.131	.020	.847
	Occup_not_look	-1.653	.984	2.820	1	.093	.192	.028	1.318
	Helio_resident	.252	1.644	.024	1	.878	1.287	.051	32.308
	Helio_working	-.853	1.671	.261	1	.610	.426	.016	11.264
	Helio_Visitor	.137	1.656	.007	1	.934	1.147	.045	29.441
	Fly_Freq_most	.660	.536	1.518	1	.218	1.935	.677	5.527
	Fly_Freq_some	.164	.524	.098	1	.754	1.178	.422	3.289
	Fly_Freq_daily	.385	.538	.513	1	.474	1.470	.512	4.221
	Age_18_25	-18.734	3437.248	.000	1	.996	7.308E-9	.000	.[b]
	Age_26_35	-19.103	3437.248	.000	1	.996	5.056E-9	.000	.[b]
	Age_36_45	-18.894	3437.248	.000	1	.996	6.227E-9	.000	.[b]
	Age_46_55	-18.607	3437.248	.000	1	.996	8.302E-9	.000	.[b]
	Age_55_65	-18.980	3437.248	.000	1	.996	5.715E-9	.000	.[b]
	Income_0_6k	.421	.377	1.248	1	.264	1.524	.728	3.190
	Income_6k_9k	.264	.463	.325	1	.568	1.303	.525	3.231
	Income_9k_12k	-.198	.528	.141	1	.708	.820	.292	2.308
	Fly_distance_1km	.784	.493	2.530	1	.112	2.191	.833	5.759
	Fly_distance_1_2km	.781	.496	2.486	1	.115	2.184	.827	5.771
	Fly_distance_more5km	-.229	.416	.302	1	.582	.796	.352	1.797
	Car_yes	1.109	.669	2.751	1	.097	3.032	.818	11.245
	Bike_yes	-.001	.495	.000	1	.998	.999	.378	2.637
	Gender_Female	.072	.325	.049	1	.825	1.074	.568	2.032
	Main_Mode_Car	-18.627	6067.390	.000	1	.998	8.132E-9	.000	.[b]
	Main_Mode_taxi	-17.266	6067.390	.000	1	.998	3.174E-8	.000	.[b]
	Main_Mode_walking	-18.523	6067.390	.000	1	.998	9.026E-9	.000	.[b]
	Main_Mode_priv_bus	-17.136	6067.390	.000	1	.998	3.615E-8	.000	.[b]
	Main_Mode_MM	-18.862	6067.390	.000	1	.998	6.432E-9	.000	.[b]
	Main_Mode_PT	-17.284	6067.390	.000	1	.998	3.116E-8	.000	.[b]
	Main_Mode_POBus	-18.850	6067.390	.000	1	.998	6.508E-9	.000	.[b]
	Main_Mode_Motor	-17.480	6067.390	.000	1	.998	2.563E-8	.000	.[b]

Shorter	Intercept	2.425	2.336	1.077	1	.299			
	Occup_employee	-.971	.814	1.426	1	.232	.379	.077	1.865
	Occup_Student	-1.106	.912	1.471	1	.225	.331	.055	1.976
	Occup_not_look	-.847	.943	.808	1	.369	.429	.068	2.720
	Helio_resident	-.635	1.380	.211	1	.646	.530	.035	7.931
	Helio_working	-1.089	1.402	.603	1	.438	.337	.022	5.260
	Helio_Visitor	-.621	1.383	.202	1	.653	.537	.036	8.073
	Fly_Freq_most	1.133	.537	4.453	1	.035	3.103	1.084	8.885
	Fly_Freq_some	.517	.523	.978	1	.323	1.677	.602	4.677
	Fly_Freq_daily	.824	.542	2.315	1	.128	2.281	.789	6.596
	Age_18_25	.547	.758	.522	1	.470	1.729	.392	7.631
	Age_26_35	.368	.704	.272	1	.602	1.444	.363	5.742
	Age_36_45	.420	.731	.331	1	.565	1.522	.363	6.377
	Age_46_55	-.392	.791	.245	1	.620	.676	.143	3.185
	Age_55_65	.046	.000	.	1	.	1.047	1.047	1.047
	Income_0_6k	-.356	.352	1.020	1	.313	.701	.351	1.398
	Income_6k_9k	-1.082	.472	5.252	1	.022	.339	.134	.855
	Income_9k_12k	.200	.457	.192	1	.662	1.221	.499	2.990
	Fly_distance_1km	.237	.463	.262	1	.609	1.268	.511	3.142
	Fly_distance_1_2km	-.180	.468	.148	1	.701	.835	.334	2.091
	Fly_distance_more5km	-.556	.371	2.250	1	.134	.573	.277	1.186
	Car_yes	.669	.643	1.084	1	.298	1.953	.554	6.887
	Bike_yes	-1.567	.590	7.054	1	.008	.209	.066	.663
	Gender_Female	-.339	.311	1.186	1	.276	.712	.387	1.312
	Main_Mode_Car	-1.200	1.615	.552	1	.458	.301	.013	7.138
	Main_Mode_taxi	-.258	1.564	.027	1	.869	.773	.036	16.557
	Main_Mode_walking	-.802	1.799	.199	1	.656	.449	.013	15.240
	Main_Mode_priv_bus	-.111	1.807	.004	1	.951	.895	.026	30.917
	Main_Mode_MM	-1.317	1.706	.596	1	.440	.268	.009	7.594
	Main_Mode_PT	-.163	1.546	.011	1	.916	.850	.041	17.594
	Main_Mode_POBus	.095	1.943	.002	1	.961	1.100	.024	49.617
	Main_Mode_Motor	-1.358	.000	.	1	.	.257	.257	.257

a. The reference category is: Same.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

Classification

	Predicted			
Observed	Longer	Same	Shorter	Percent Correct
Longer	72	12	63	49.0%
Same	24	13	50	14.9%
Shorter	33	9	152	78.4%
Overall Percentage	30.1%	7.9%	61.9%	55.4%

Trip Duration

Case Processing Summary

		N	Marginal Percentage
Trip_duration	Decrease	219	51.2%
	Increase	36	8.4%
	Same	173	40.4%
Valid		428	100.0%
Missing		0	
Total		428	
Subpopulation		346[a]	

a. The dependent variable has only one value observed in 313 (90.5%) subpopulations.

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	713.815			
Final	594.879	118.936	56	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	740.827	634	.002
Deviance	541.960	634	.997

Pseudo R-Square

Cox and Snell	.243
Nagelkerke	.289
McFadden	.151

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	597.340	2.461	2	.292
Income_3k_6k	599.807	4.928	2	.085
Income_6k_9k	596.031	1.152	2	.562
Income_9k_12k	597.482	2.603	2	.272
Income_more20k	597.835	2.956	2	.228
Income_12k_20k	595.685	.806	2	.668
Main_Mode_Car	596.156	1.277	2	.528
Main_Mode_taxi	596.015	1.136	2	.567
Main_Mode_walking	595.991	1.112	2	.574
Main_Mode_priv_bus	595.921	1.043	2	.594
Main_Mode_Motor	596.457	1.578	2	.454
Gender_Female	623.257	28.378	2	.000
Fly_Freq_most	597.419	2.540	2	.281
Fly_Freq_some	596.816	1.937	2	.380
Fly_Freq_daily	604.030	9.151	2	.010
Fly_distance_1km	599.266	4.387	2	.112
Fly_distance_1_2km	597.634	2.755	2	.252
Fly_distance_more5km	599.729	4.850	2	.088
Car_yes	601.828	6.949	2	.031
Bike_yes	600.857	5.978	2	.050
Occup_employee	596.584	1.705	2	.426
Occup_Student	595.909	1.030	2	.598
Occup_not_look	596.747	1.868	2	.393
Main_Mode_MM	595.708	.829	2	.661
Main_Mode_PT	595.726	.847	2	.655
Main_Mode_POBus	596.262	1.384	2	.501
Age_18_25	599.156	4.277	2	.118
Age_26_45	600.835	5.956	2	.051
Age_46_65	610.378	15.499	2	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Parameter Estimates

Trip_duration[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Decrease	Intercept	17.783	5441.893	.000	1	.997			
	Income_3k_6k	-.536	.331	2.625	1	.105	.585	.306	1.119
	Income_6k_9k	-.341	.391	.759	1	.384	.711	.331	1.531
	Income_9k_12k	.211	.401	.276	1	.600	1.235	.562	2.712
	Income_more20k	.793	.521	2.318	1	.128	2.210	.796	6.134
	Income_12k_20k	-.366	.413	.786	1	.375	.693	.308	1.558
	Main_Mode_Car	-17.348	5441.893	.000	1	.997	2.923E-8	.000	.[b]
	Main_Mode_taxi	-17.149	5441.893	.000	1	.997	3.567E-8	.000	.[b]
	Main_Mode_walking	-17.269	5441.893	.000	1	.997	3.164E-8	.000	.[b]
	Main_Mode_priv_bus	-17.203	5441.893	.000	1	.997	3.379E-8	.000	.[b]
	Main_Mode_Motor	-18.097	5441.894	.000	1	.997	1.382E-8	.000	.[b]
	Gender_Female	-.838	.252	11.023	1	.001	.432	.264	.709
	Fly_Freq_most	.716	.465	2.374	1	.123	2.046	.823	5.085
	Fly_Freq_some	.529	.462	1.308	1	.253	1.697	.686	4.200
	Fly_Freq_daily	1.231	.467	6.932	1	.008	3.424	1.370	8.559
	Fly_distance_1km	.412	.341	1.464	1	.226	1.510	.775	2.943
	Fly_distance_1_2km	-.187	.352	.283	1	.595	.829	.416	1.653
	Fly_distance_more5km	.191	.301	.402	1	.526	1.210	.671	2.183
	Car_yes	.746	.480	2.409	1	.121	2.108	.822	5.403
	Bike_yes	-.814	.437	3.473	1	.062	.443	.188	1.043
	Occup_employee	-.021	.475	.002	1	.964	.979	.386	2.481
	Occup_Student	-.513	.581	.778	1	.378	.599	.192	1.871
	Occup_not_look	.244	.638	.146	1	.702	1.276	.366	4.452
	Main_Mode_MM	-16.876	5441.893	.000	1	.998	4.688E-8	.000	.[b]
	Main_Mode_PT	-16.683	5441.893	.000	1	.998	5.682E-8	.000	.[b]
	Main_Mode_POBus	-17.654	5441.894	.000	1	.997	2.153E-8	.000	.[b]
	Age_18_25	-1.040	.731	2.023	1	.155	.354	.084	1.481
	Age_26_45	-1.205	.683	3.111	1	.078	.300	.079	1.143
	Age_46_65	-2.505	.763	10.791	1	.001	.082	.018	.364

Increase	Intercept	-2.229	2.245	.986	1	.321			
	Income_3k_6k	.590	.577	1.045	1	.307	1.804	.582	5.594
	Income_6k_9k	.294	.753	.153	1	.696	1.342	.307	5.867
	Income_9k_12k	-1.412	1.168	1.461	1	.227	.244	.025	2.405
	Income_more20k	-.301	1.235	.059	1	.808	.740	.066	8.332
	Income_12k_20k	-.327	.940	.121	1	.728	.721	.114	4.548
	Main_Mode_Car	-2.428	1.393	3.036	1	.081	.088	.006	1.354
	Main_Mode_taxi	-.756	1.413	.286	1	.593	.470	.029	7.490
	Main_Mode_walking	-1.910	1.813	1.110	1	.292	.148	.004	5.172
	Main_Mode_priv_bus	-17.825	2878.299	.000	1	.995	1.814E-8	.000	.[b]
	Main_Mode_Motor	-15.477	6436.064	.000	1	.998	1.898E-7	.000	.[b]
	Gender_Female	1.350	.474	8.100	1	.004	3.858	1.522	9.775
	Fly_Freq_most	.088	.670	.017	1	.896	1.092	.294	4.061
	Fly_Freq_some	-.323	.692	.218	1	.641	.724	.187	2.809
	Fly_Freq_daily	-.410	.716	.327	1	.567	.664	.163	2.701
	Fly_distance_1km	1.428	.770	3.436	1	.064	4.171	.921	18.882
	Fly_distance_1_2km	1.033	.754	1.874	1	.171	2.809	.640	12.321
	Fly_distance_more5km	1.451	.710	4.178	1	.041	4.267	1.061	17.153
	Car_yes	1.880	.789	5.677	1	.017	6.552	1.396	30.760
	Bike_yes	.759	.718	1.115	1	.291	2.135	.522	8.727
	Occup_employee	1.296	1.165	1.236	1	.266	3.653	.372	35.862
	Occup_Student	.418	1.375	.092	1	.761	1.518	.103	22.486
	Occup_not_look	1.720	1.354	1.614	1	.204	5.583	.393	79.297
	Main_Mode_MM	-16.728	2639.338	.000	1	.995	5.436E-8	.000	.[b]
	Main_Mode_PT	-.176	1.419	.015	1	.901	.838	.052	13.524
	Main_Mode_POBus	-.571	.000	.	1	.	.565	.565	.565
	Age_18_25	-1.987	1.047	3.599	1	.058	.137	.018	1.068
	Age_26_45	-2.076	.970	4.575	1	.032	.125	.019	.841
	Age_46_65	-2.918	1.226	5.669	1	.017	.054	.005	.597

a. The reference category is: Same.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

Classification

	Predicted			
Observed	Decrease	Increase	Same	Percent Correct
Decrease	169	0	50	77.2%
Increase	12	7	17	19.4%
Same	82	5	86	49.7%
Overall Percentage	61.4%	2.8%	35.7%	61.2%

Route Choice

Case Processing Summary

		N	Marginal Percentage
Route_choice	No	118	27.6%
	Yes	310	72.4%
Valid		428	100.0%
Missing		0	
Total		428	
Subpopulation		318[a]	

a. The dependent variable has only one value observed in 288 (90.6%) subpopulations.

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	429.716			
Final	376.238	53.479	22	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	299.290	295	.420
Deviance	327.708	295	.092

Pseudo R-Square

Cox and Snell	.117
Nagelkerke	.170
McFadden	.106

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	377.168	.931	1	.335
Income_0_6k	379.758	3.521	1	.061
Income_6_12k	378.830	2.593	1	.107
Income_morethan12	381.692	5.455	1	.020
Fly_Freq_most	376.405	.168	1	.682
Fly_Freq_some	376.252	.014	1	.905
Fly_Freq_daily	376.308	.070	1	.791
Helio_resident	376.371	.134	1	.715
Helio_working	376.908	.670	1	.413
Helio_Visitor	376.940	.702	1	.402
Gender_Female	378.018	1.780	1	.182
Fly_distance_1km	378.873	2.635	1	.105
Fly_distance_1_2km	381.729	5.491	1	.019
Fly_distance_more5km	377.817	1.579	1	.209
Main_Mode_Car	376.973	.736	1	.391
Main_Mode_taxi	376.580	.343	1	.558
Main_Mode_walking	377.041	.803	1	.370
Main_Mode_priv_bus	376.816	.579	1	.447
Main_Mode_Motor	376.475	.237	1	.626
Main_Mode_Mass	376.638	.401	1	.527
Car_yes	386.196	9.959	1	.002
Age_18_25	384.508	8.271	1	.004
Age_26_45	381.752	5.514	1	.019

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Parameter Estimates

Route_choice[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	95% Confidence Interval for Exp(B) Upper Bound
Yes	Intercept	16.316	1.280	162.510	1	.000			
	Income_0_6k	.528	.284	3.463	1	.063	1.695	.972	2.955
	Income_6_12k	.623	.395	2.483	1	.115	1.864	.859	4.044
	Income_morethan12	.901	.401	5.039	1	.025	2.462	1.121	5.409
	Fly_Freq_most	.184	.448	.169	1	.681	1.202	.500	2.890
	Fly_Freq_some	.052	.438	.014	1	.905	1.054	.447	2.486
	Fly_Freq_daily	-.121	.456	.070	1	.792	.886	.363	2.168
	Helio_resident	-.445	1.250	.127	1	.722	.641	.055	7.426
	Helio_working	-.988	1.266	.609	1	.435	.372	.031	4.454
	Helio_Visitor	-1.003	1.257	.636	1	.425	.367	.031	4.313
	Gender_Female	-.340	.254	1.787	1	.181	.712	.433	1.172
	Fly_distance_1km	.591	.366	2.611	1	.106	1.806	.882	3.700
	Fly_distance_1_2km	.925	.404	5.245	1	.022	2.523	1.143	5.570
	Fly_distance_more5km	.391	.312	1.577	1	.209	1.479	.803	2.723
	Main_Mode_Car	-15.710	.542	838.939	1	.000	1.504E-7	5.196E-8	4.356E-7
	Main_Mode_taxi	-14.853	.476	975.230	1	.000	3.544E-7	1.395E-7	9.002E-7
	Main_Mode_walking	-15.922	.879	328.294	1	.000	1.216E-7	2.173E-8	6.808E-7
	Main_Mode_priv_bus	-15.500	.777	398.144	1	.000	1.855E-7	4.048E-8	8.505E-7
	Main_Mode_Motor	-14.522	1.285	127.619	1	.000	4.933E-7	3.971E-8	6.128E-6
	Main_Mode_Mass	-15.025	.000	.	1	.	2.984E-7	2.984E-7	2.984E-7
	Car_yes	1.502	.510	8.680	1	.003	4.492	1.653	12.202
	Age_18_25	-1.288	.480	7.198	1	.007	.276	.108	.707
	Age_26_45	-1.005	.459	4.795	1	.029	.366	.149	.900

a. The reference category is: No.

Classification

Observed	Predicted No	Predicted Yes	Predicted Percent Correct
No	23	95	19.5%
Yes	19	291	93.9%
Overall Percentage	9.8%	90.2%	73.4%

Affected NMT

Case Processing Summary

		N	Marginal Percentage
NMT	No	126	29.4%
	Yes	302	70.6%
Valid		428	100.0%
Missing		5	
Total		433	
Subpopulation		116[a]	

a. The dependent variable has only one value observed in 79 (68.1%) subpopulations.

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	230.923			
Final	209.922	21.001	12	.050

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	107.271	103	.367
Deviance	127.024	103	.054

Pseudo R-Square

Cox and Snell	.048
Nagelkerke	.068
McFadden	.040

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	210.045	.123	1	.725
Helio_resident	210.035	.114	1	.736
Helio_working	210.068	.146	1	.703
Helio_Visitor	210.664	.742	1	.389
Age_18_25	213.916	3.995	1	.046
Age_26_45	214.569	4.647	1	.031
Age_46_65	211.271	1.349	1	.245
Fly_distance_0_2	213.374	3.452	1	.063
Fly_distance_3_5	211.206	1.285	1	.257
Bike_yes	212.476	2.554	1	.110
Fly_Freq_daily	211.266	1.345	1	.246
Fly_freqency_rare	210.242	.320	1	.572
Fly_Freq_most	209.935	.014	1	.907

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Parameter Estimates

NMT[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Yes	Intercept	.448	1.304	.118	1	.731			
	Helio_resident	-.395	1.202	.108	1	.743	.674	.064	7.104
	Helio_working	-.459	1.235	.138	1	.710	.632	.056	7.113
	Helio_Visitor	-.991	1.217	.663	1	.416	.371	.034	4.033
	Age_18_25	.986	.491	4.040	1	.044	2.680	1.025	7.010
	Age_26_45	1.023	.470	4.732	1	.030	2.782	1.107	6.993
	Age_46_65	.649	.560	1.341	1	.247	1.913	.638	5.735
	Fly_distance_0_2	.567	.311	3.330	1	.068	1.763	.959	3.243
	Fly_distance_3_5	.307	.273	1.262	1	.261	1.359	.796	2.320
	Bike_yes	.765	.512	2.233	1	.135	2.148	.788	5.857
	Fly_Freq_daily	-.367	.317	1.335	1	.248	.693	.372	1.291
	Fly_freqency_rare	.245	.436	.315	1	.575	1.277	.543	3.003
	Fly_Freq_most	-.034	.296	.014	1	.907	.966	.541	1.724

a. The reference category is: No.

Classification

Observed	Predicted No	Yes	Percent Correct
No	3	123	2.4%
Yes	5	297	98.3%
Overall Percentage	1.9%	98.1%	70.1%

Connectivity

Case Processing Summary

		N	Marginal Percentage
Connectivity	No, it is the same	150	35.0%
	Yes, more destinations easier now	63	14.7%
	Yes, same destinations faster now	192	44.9%
	Yes, same destinations in shorter dista	23	5.4%
Valid		428	100.0%
Missing		0	
Total		428	
Subpopulation		255[a]	

a. The dependent variable has only one value observed in 192 (75.3%) subpopulations.

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	808.395			
Final	674.150	134.245	54	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	693.212	708	.647
Deviance	545.626	708	1.000

Pseudo R-Square

Cox and Snell	.269
Nagelkerke	.298
McFadden	.134

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	676.949	2.799	3	.424
Fly_Freq_most	698.196	24.046	3	.000
Fly_Freq_some	682.690	8.540	3	.036
Fly_Freq_daily	697.742	23.592	3	.000
Fly_distance_1km	682.160	8.010	3	.046
Fly_distance_1_2km	680.229[a]	6.079	3	.108
Fly_distance_more5km	686.126[a]	11.976	3	.007
Gender_Female	689.804[a]	15.655	3	.001
Main_Mode_Car	674.825[a]	.675	3	.879
Main_Mode_taxi	675.538[a]	1.388	3	.708
Main_Mode_walking	675.397[a]	1.247	3	.742
Main_Mode_priv_bus	675.288[a]	1.138	3	.768
Main_Mode_Motor	677.489	3.339	3	.342
Main_Mode_Mass	675.030[a]	.880	3	.830
Age_18_35	680.800[a]	6.650	3	.084
Age_36_55	681.296[a]	7.146	3	.067
Income_6k_9k	683.017[a]	8.867	3	.031
Income_0_6k	680.665[a]	6.515	3	.089
Income_9_20k	678.172[a]	4.022	3	.259

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.

Classification

Observed	Predicted No, it is the same	Yes, more destinations easier now	Yes, same destinations faster now	Yes, same destinations in shorter dista	Percent Correct
No, it is the same	83	2	65	0	55.3%
Yes, more destinations easier now	7	12	44	0	19.0%
Yes, same destinations faster now	43	4	145	0	75.5%
Yes, same destinations in shorter dista	11	1	10	1	4.3%
Overall Percentage	33.6%	4.4%	61.7%	0.2%	56.3%

Parameter Estimates

								95% Confidence Interval for Exp(B)	
Connectivity[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	Lower Bound	Upper Bound
No, it is the same	Intercept	.491	1193.474	.000	1	1.000			
	Fly_Freq_most	-.261	.748	.122	1	.727	.770	.178	3.336
	Fly_Freq_some	-.044	.733	.004	1	.952	.957	.228	4.023
	Fly_Freq_daily	.544	.824	.435	1	.509	1.722	.343	8.654
	Fly_distance_1km	-1.706	.882	3.740	1	.053	.182	.032	1.023
	Fly_distance_1_2km	-.314	.998	.099	1	.753	.731	.103	5.165
	Fly_distance_more5km	-1.045	.839	1.550	1	.213	.352	.068	1.822
	Gender_Female	-.084	.480	.031	1	.861	.919	.359	2.354
	Main_Mode_Car	1.564	1193.473	.000	1	.999	4.779	.000	.[b]
	Main_Mode_taxi	1.900	1193.473	.000	1	.999	6.683	.000	.[b]
	Main_Mode_walking	1.427	1193.474	.000	1	.999	4.166	.000	.[b]
	Main_Mode_priv_bus	14.811	1394.442	.000	1	.992	2705024.624	.000	.[b]
	Main_Mode_Motor	-.034	1193.474	.000	1	1.000	.966	.000	.[b]
	Main_Mode_Mass	1.833	1193.473	.000	1	.999	6.251	.000	.[b]
	Age_18_35	-.050	1.179	.002	1	.966	.951	.094	9.597
	Age_36_55	1.161	1.294	.806	1	.369	3.194	.253	40.332
	Income_6k_9k	1.121	.872	1.651	1	.199	3.068	.555	16.957
	Income_0_6k	.890	.576	2.384	1	.123	2.435	.787	7.538
	Income_9_20k	.205	.686	.089	1	.765	1.227	.320	4.711
Yes, more destinations easier now	Intercept	-12.032	1854.680	.000	1	.995			
	Fly_Freq_most	13.666	220.135	.004	1	.951	860753.492	3.593E-182	2.062E+193
	Fly_Freq_some	12.551	220.135	.003	1	.955	282359.458	1.179E-182	6.765E+192
	Fly_Freq_daily	14.392	220.136	.004	1	.948	1778980.387	7.421E-182	4.264E+193
	Fly_distance_1km	-1.607	.957	2.823	1	.093	.200	.031	1.307
	Fly_distance_1_2km	-.766	1.075	.508	1	.476	.465	.056	3.823
	Fly_distance_more5km	-.292	.904	.105	1	.746	.747	.127	4.390
	Gender_Female	-.974	.545	3.188	1	.074	.378	.130	1.100
	Main_Mode_Car	1.860	1841.569	.000	1	.999	6.426	.000	.[b]
	Main_Mode_taxi	2.133	1841.569	.000	1	.999	8.444	.000	.[b]
	Main_Mode_walking	1.752	1841.569	.000	1	.999	5.764	.000	.[b]
	Main_Mode_priv_bus	14.690	1977.743	.000	1	.994	2396898.770	.000	.[b]
	Main_Mode_Motor	-18.792	10167.457	.000	1	.999	6.901E-9	.000	.[b]
	Main_Mode_Mass	1.062	1841.569	.000	1	1.000	2.892	.000	.[b]
	Age_18_35	-1.267	1.186	1.141	1	.285	.282	.028	2.881
Yes, same destinations faster now	Intercept	13.401	1.564	73.433	1	.000			
	Fly_Freq_most	1.119	.790	2.010	1	.156	3.063	.652	14.397
	Fly_Freq_some	.500	.783	.408	1	.523	1.649	.356	7.643
	Fly_Freq_daily	1.762	.864	4.158	1	.041	5.826	1.071	31.703
	Fly_distance_1km	-2.098	.874	5.770	1	.016	.123	.022	.680
	Fly_distance_1_2km	-1.185	.998	1.411	1	.235	.306	.043	2.161
	Fly_distance_more5km	-1.544	.837	3.403	1	.065	.213	.041	1.101
	Gender_Female	-.992	.482	4.231	1	.040	.371	.144	.954
	Main_Mode_Car	-11.241	.668	283.571	1	.000	1.313E-5	3.549E-6	4.858E-5
	Main_Mode_taxi	-11.887	.922	166.362	1	.000	6.881E-6	1.130E-6	4.189E-5
	Main_Mode_walking	-12.308	1.408	76.415	1	.000	4.517E-6	2.860E-7	7.134E-5
	Main_Mode_priv_bus	1.088	721.174	.000	1	.999	2.967	.000	.[b]
	Main_Mode_Motor	-32.322	7825.230	.000	1	.997	9.176E-15	.000	.[b]
	Main_Mode_Mass	-11.577	.000	.	1	.	9.380E-6	9.380E-6	9.380E-6
	Age_18_35	.264	1.163	.052	1	.820	1.302	.133	12.714
	Age_36_55	1.342	1.277	1.104	1	.293	3.826	.313	46.766
	Income_6k_9k	.692	.870	.633	1	.426	1.998	.363	10.997
	Income_0_6k	.617	.581	1.127	1	.288	1.853	.593	5.786
	Income_9_20k	.689	.667	1.067	1	.302	1.992	.539	7.362

a. The reference category is: Yes, same destinations in shorter dista.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

Trips Affected

Case Processing Summary

		N	Marginal Percentage
Daily_trips	No	107	25.0%
	Yes	321	75.0%
Valid		428	100.0%
Missing		0	
Total		428	
Subpopulation		355[a]	

a. The dependent variable has only one value observed in 335 (94.4%) subpopulations.

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	439.111			
Final	384.934	54.176	29	.003

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	334.402	325	.348
Deviance	353.718	325	.131

Pseudo R-Square

Cox and Snell	.119
Nagelkerke	.176
McFadden	.113

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	384.934	.000	1	.994
Helio_resident	384.956	.021	1	.884
Helio_working	384.963	.028	1	.866
Helio_Visitor	385.414	.480	1	.489
Fly_Freq_most	397.025	12.091	1	.001
Fly_Freq_some	391.451	6.517	1	.011
Fly_Freq_daily	392.420	7.486	1	.006
Main_Mode_Car	388.960	4.026	1	.045
Main_Mode_taxi	388.903	3.969	1	.046
Main_Mode_walking	389.254	4.319	1	.038
Main_Mode_priv_bus	390.306	5.371	1	.020
Main_Mode_MM	388.103	3.169	1	.075
Main_Mode_PT	389.941	5.006	1	.025
Main_Mode_POBus	389.452	4.518	1	.034
Main_Mode_Motor	387.802	2.868	1	.090
Gender_Female	384.935	.001	1	.982
Income_less3000	385.581	.647	1	.421
Income_3k_6k	386.065	1.131	1	.288
Income_6k_9k	384.992	.057	1	.811
Income_9k_12k	386.921	1.986	1	.159
Income_12k_20k	385.195	.260	1	.610
Fly_distance_1km	385.156	.222	1	.638
Fly_distance_1_2km	386.798	1.864	1	.172
Fly_distance_more5km	385.066	.132	1	.717
Car_yes	386.299	1.364	1	.243
Bike_yes	385.136	.201	1	.654
Age_18_35	387.113	2.179	1	.140
Age_36_45	386.165	1.231	1	.267
Age_46_55	386.047	1.113	1	.291
Age_55_65	387.525	2.590	1	.108

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Parameter Estimates

Daily_trips[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Yes	Intercept	-3.932	2.154	3.332	1	.068			
	Helio_resident	.222	1.512	.022	1	.883	1.248	.064	24.188
	Helio_working	-.256	1.536	.028	1	.868	.774	.038	15.712
	Helio_Visitor	-.994	1.503	.437	1	.508	.370	.019	7.045
	Fly_Freq_most	1.575	.457	11.861	1	.001	4.832	1.971	11.842
	Fly_Freq_some	1.116	.441	6.418	1	.011	3.053	1.287	7.242
	Fly_Freq_daily	1.255	.461	7.414	1	.006	3.506	1.421	8.650
	Main_Mode_Car	21.077	1.461	208.200	1	.000	1424026285.332	81313026.736	24938819064.084
	Main_Mode_taxi	21.139	1.424	220.218	1	.000	1515077126.043	92881045.599	24713962714.950
	Main_Mode_walking	21.599	1.664	168.418	1	.000	2401530082.213	91998763.907	62689393757.741
	Main_Mode_priv_bus	22.233	1.650	181.488	1	.000	4524810111.169	178170583.303	114911823054.872
	Main_Mode_MM	20.766	1.561	176.989	1	.000	1043772876.880	48971465.600	22246869787.352
	Main_Mode_PT	21.756	1.422	233.927	1	.000	2809265772.676	172896205.034	45645733982.352
	Main_Mode_POBus	21.936	1.838	142.434	1	.000	3363186352.341	91667588.732	123391730894.048
	Main_Mode_Motor	20.913	.000	.	1	.	1208967464.158	1208967464.158	1208967464.158
	Gender_Female	.005	.266	.000	1	.984	1.005	.596	1.695
	Income_less3000	.386	.486	.632	1	.427	1.471	.568	3.812
	Income_3k_6k	.354	.334	1.122	1	.289	1.424	.740	2.739
	Income_6k_9k	.099	.413	.057	1	.811	1.104	.492	2.477
	Income_9k_12k	.639	.468	1.868	1	.172	1.895	.758	4.741
	Income_12k_20k	.222	.439	.257	1	.613	1.249	.529	2.950
	Fly_distance_1km	-.192	.408	.221	1	.638	.825	.371	1.836
	Fly_distance_1_2km	-.539	.396	1.852	1	.174	.583	.269	1.268
	Fly_distance_more5km	.123	.338	.132	1	.717	1.130	.583	2.192
	Car_yes	.586	.510	1.320	1	.251	1.796	.661	4.878
	Bike_yes	.228	.516	.195	1	.658	1.256	.457	3.454
	Age_18_35	-17.731	.590	903.366	1	.000	1.994E-8	6.274E-9	6.336E-8
	Age_36_45	-17.014	.652	680.249	1	.000	4.082E-8	1.137E-8	1.466E-7
	Age_46_55	-16.923	.766	488.309	1	.000	4.472E-8	9.968E-9	2.006E-7
	Age_55_65	-18.089	.000	.	1	.	1.393E-8	1.393E-8	1.393E-8

a. The reference category is: No.

Classification

Observed	Predicted No	Yes	Percent Correct
No	20	87	18.7%
Yes	9	312	97.2%
Overall Percentage	6.8%	93.2%	77.6%

آثار البنية التحتية المرتفعة للنقل على البيئة الحضرية

تأثير الجسور على سلوك السفر الحضري؛ دراسة حالة مصر الجديدة

اعداد: ساره أبو هنيدى

أصبحت مناهج التنقل حاليا في مصر تركز على توسيع البنية التحتية للطرق داخل المدن وبين بعضها البعض. ومع زيادة التوسع الحضري، أصبح إنشاء روابط جديدة بين المدن المختلفة ومناطقها، بالإضافة إلى زيادة القدرة الاستيعابية للروابط الحالية، من الاولويات. وبالتالي، فإن حركة بناء الجسور العلوية أصبحت تحدث في مصر وخاصة في القاهرة. تم التخطيط للبنية التحتية بأن تشمل الجسور المرتفعة للنقل لتصبح أداة أساسية لحل مشاكل المرور داخل المدن وذلك لتمكين تنقل أسرع وأفضل للمواطنين.

يؤثر هذا النوع من البنى التحتية للنقل على البيئة الحضرية بجميع أبعادها البيئية والاجتماعية والمادية، بما في ذلك التنقل والنقل. وبالتالي، فإن الغرض من هذا البحث هو فحص هذه التأثيرات، مع التركيز على التأثيرات المتعلقة بسلوك السفر الحضري.

أجريت الدراسة على مقياسين، أحدهما على النطاق الكلي متمثلا في مدينة القاهرة والآخر على النطاق المجهري متمثلا في منطقة مصر الجديدة. وتم تحديد الآثار من خلال مقارنة عدة جوانب بين فترتين، قبل تشييد الجسور المرتفعة وبعدها. تم تحليل الازدحام المروري قبل وبعد إنشاء الجسور العلوية عن طريق استخدام التحليل البصري القائم على بيانات السيارة العائمة وذلك لتحديد آثار الجسور على النطاق الكلي (القاهرة). اما عن النطاق المجهري (مصر الجديدة)، تم إجراء استبيان سلوك السفر ونشره عبر الإنترنت لفحص العديد من مواصفات سلوك السفر، مثل وقت السفر واختيار المسار وما إلى ذلك لتحديد التغييرات التي تأثرت بالجسور العلوية. تم تحليل نتائج الاستبيان بمنهج نوعي وكمي باستخدام نماذج التحليل الإحصائي.

من خلال تحليل كلا المقياسين، استطاع الباحث التعرف على العديد من التغييرات في سلوك السفر الناتجة عن إنشاء الجسور العلوية. ساهمت بعض هذه التغييرات في تحسين حركة التنقل، حيث انها جعلت بعض الرحلات أسرع وأقصر بالإضافة الي تقليل الازدحام بالشوارع، بينما اثر البعض الآخر سلبًا على حركة المجتمع من خلال التأثير على اختيارالافراد للمسار، بالإضافة إلى سلامة السفر النشط.

هناك حاجة إلى مزيد من البحث لدراسة التأثيرات على أبعاد البيئة الحضرية الأخرى وكذلك تقييم هذه البنى التحتية المرتفعة للنقل كأداة لحل مشاكل التنقل والمرور.

الكلمات الرئيسية: الجسور العلوية. إمكانية التنقل، سلوك السفر الحضري، مقياسي النطاق الكلي و المجهري، تحليل الازدحام، استبيان سلوك السفر، القاهرة، مصر الجديدة، بيانات السيارة العائمة، التحليل البصرى، واصفات سلوك السفر.

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام .إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة 2020

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث :ساره أبو هنيدى

التاريخ: 2020

آثار البنية التحتية المرتفعة للنقل على البيئة الحضرية

تأثير الجسور على سلوك السفر الحضري؛
دراسة حالة مصر الجديدة

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

أعداد :ساره طارق أبو هنيدى

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لجنة الحكم

أ.د........ .الممتحن الخارجي
أستاذ ....
جامعة ....

التوقيع

أ.د........ .
أستاذ ....
جامعة ....

أ.د........ .
أستاذ ....
جامعة ....

تاريخ المناقشة..............:

الدراسات العليا

أجيزت الرسالة بتاريخ............:

موافقة مجلس الجامعة .../.../...

ختم الإجازة

موافقة مجلس الكلية .../.../...

جامعة عين شـــــمس

2020