ALTERNATIVE
POLICY
SOLUTIONS

POLICY PAPER

Towards Transit-Centric New Desert Communities in the Greater Cairo Region

June 2019

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Mohamed Hegazy[a]
Author

Adham Kalila[a]
Co-author

Jacqueline M Klopp[b]
Co-author

Sara Abu Henedy[a]
Designer

Alternative Policy Solutions
113 Qasr al-Einy street
PO Box 12511
Cairo - Postal Code: 11511
Egypt
02 2797 6970
http://aps.aucegypt.edu – solutions@aucegypt.edu

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[a] Transport for Cairo (TfC), 4 Road 160 Maadi, Cairo, Egypt.
[b] Center for Sustainable Urban Development, Earth Institute, Columbia University, 475 Riverside Drive, Suite 520, New York, NY 10115, USA.

Alternative Policy Solutions is a non-partisan, public policy research project at The American University in Cairo. Using rigorous, in-depth research and a participatory process of consultations with a diverse range of stakeholders, we propose evidence-based policy solutions to some of the most difficult challenges facing Egypt. Our solutions are innovative, forward-looking and designed to support decision makers' efforts to introduce inclusive public policies.

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List of Acronyms

BRT	Bus Rapid Transit
CBD	Central Business District
CETUD	Conseil Exécutif des Transports Urbains de Dakar
EASI	Enable - Avoid - Shift - Improve
GCR	Greater Cairo Region
GTFS	General Transit Feed Specification
NDC	New Desert Communities
NUCA	New Urban Communities Authority
O-D	Origin - Destnation
OSM	Open Street Map
OTP	Open Trip Planner
PTA	Public Transport Authority
SDG	Sustainable Development Goals
SDS	Sustainable Development Strategy of Egypt 2030
SSATP	Sub-Saharan Africa Transport Policy Program
SUMP	Sustainable Urban Transport Plan
TfC	Transport for Cairo
TICD	Takween Integrated Community Development
UITP	Union Internationale de Transport Publique
VMT	Vehicle Miles Travelled

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Executive Summary

This policy paper suggests solutions for utilizing urban mobility within the New Desert Communities (NDCs) to improve the living conditions of existing residents and attract more people to currently vacant housing, rather than simply continuing to focus on expansion. Specifically, using new transit data, this paper develops a citizen-centric model of urban accessibility that measures mobility and connectivity within NDCs and to other parts of the Greater Cairo Region (GCR). This model is innovative in including services provided by paratransit – known as informal transport hitherto understudied and overlooked despite providing the majority of transit connectivity across the GCR. The paper computes the Journey Gap, i.e. the difference in time between taking a private car or using public transit, while propositioning it as a leading indicator.

The study chooses El-Sheikh Zayed City as an example to analyze movements within NDCs due to its relatively small size as a NDC, its monocentric internal network where all services start at Hyper One, and its clear borders where all services end within the NDC borders. Moreover, the paper provides a quick overview of the transport plans for some of the world's most successful megacities, which face similar problems to Cairo. The cities explored are London, Los Angeles, and Paris. Moving forward, it presents an established global conceptual framework for urban mobility governance and policy-making tailored for the African and Middle Eastern context. The Enable - Avoid - Shift - Improve (EASI) framework consists of four pillars; each pillar is accompanied by a case study from a city in a developing country (Nigeria, South Africa, Senegal, Colombia).

The suggested recommendations aim to decrease journey times for public transport and walking. It suggests a long-term vision to improve accessibility of services and opportunities for all through better public transit, while simultaneously reducing the reliance on private vehicles. It hopes to enliven the NDC by fundamentally targeting the loss of accessibility due to relocation, while simultaneously avoiding an environmentally unfriendly and congested future. The paper presents a package of suggestions to improve mobility within El-Sheikh Zayed City based on EASI framework.

To achieve sustainable change in the urban mobility domain, some enabling policies at the national scale are suggested to shift modal share away from private cars and towards a mix of public transit and non-motorized modes of travel. Recommendations further span the regional and local level. They focus on reducing the identified journey time gap, ameliorating service and thus (a) moving people away from private cars and towards transit and (b) enhancing the accessibility of NDC residents, contributing to population relocation and NDC development towards functioning communities.

While the current proposals are aimed at El-Sheikh Zayed City in particular, they are generalizable in some form or modification to the other seven NDCs within the GCR, as well as for creating a guide for the development of the New Administrative Capital. Even though a commonality exists, the proposals should not be understood as recommendations for urban mobility within inner-city Cairo. The complex nature and importance of geographic context dictates a separate analysis and set of recommendations for the dense inner-city of Cairo, to be focused on separately.

1. Introduction[1]

Egypt faces a significant demographic and urban expansion, where an entire population lives on only 7.7% of the land (Abd El Kader, 2011). Congestion, which affects both cars and buses, in the capital alone costs the national economy 2.3% of annual GDP. In response to urbanization and congestion, the government has encouraged the suburbanization of desert land through "New Desert Communities" (NDCs). These growing communities face pressing issues including providing day-to-day essential services to residents, especially transportation.

In spite of their potential, NDCs have not reached their full capacity. David Sims calculated that NDCs have attracted on average a fifth of their target population (Sims, 2015). Located about 10 to 50km from the center, NDCs connect poorly to downtown Cairo via a few highways. Inadequate services, long commutes to work, and the added cost of travelling long distances may explain why over half of affordable public housing units developed within NDCs remain vacant (Sims, 2015; Shalabi, 2018). Road transport is the predominant mode of transport in terms of passenger and freight movement. As the national government continues to expand the road network, this induces demand. Motorization rates are growing, and private car ownership is increasing at triple the rate of population growth. Motorcycles, auto rickshaws (tok-tok), and other forms of private motorized transport are proliferating. Often painted in a negative light, more informal forms of transit[2] including minibuses or microbuses fill the gap left behind by ageing formal transit modes and lack of investment in public transport upgrading, helping to make NDCs function and connect to each other and downtown Cairo. These informal buses are often called paratransit because of their unscheduled and flexible service.

Cognizant of the importance of mobility and access for development, the UN has included urban transport directly in its Sustainable Development Goals (SDGs) as Target 11.2. Transportation sits at the intersection of multiple SDGs, such as health, climate, economic growth and social equity. Improving transport service provision in NDCs, particularly through public transport, could help fulfill Egypt's international commitments, make the Greater Cairo Region (GCR) more integrated, increase the labor market productivity, and improve livability for citizens.

For these reasons, it is critical to investigate how to improve urban mobility within NDCs to provide better living conditions for existing residents, while at the same time attracting more people to currently vacant housing. With this aim, this policy paper draws on new transit data to develop a citizen-centric model for improving NDC accessibility, defined following Geurs and Van Wee (2004) as "the extent to which land-use and transport systems enable individuals to reach activities or destinations by means of a combination of transport modes." Using the metric of the Journey Gap between travel by car and transit to analyze existing NDC patterns of movement, we show that a combination of transit improvements, effective governance mechanisms, smart solutions and land-use changes have the potential to reduce journey gaps, enabling more accessibility and allowing NDCs to attract their target population.

The paper starts by explaining the research methodology. It then moves to analyzing district-level accessibility scores and journey gaps within two western New Desert Communities, Sixth of October and El-Sheikh Zayed City. Section four highlights transport plans of the world's most successful cities, which face problems similar to those facing Cairo. Next, the paper presents the Enable - Avoid - Shift - Improve (EASI) framework, which is an established global conceptual framework for urban mobility governance and policy-making. Finally, section five proposes a number of policies to improve NDC accessibility and assesses each individually for its potential contribution to the Journey Gap.

1 More information about the transportation system in Egypt is in the background paper associated with this policy document.
2 Transit is used to denote collective modes of transport accessible to the public. Transit is used synonymously with public transport.

2. Data and Methodology

2.1. Operational Definitions

Accessibility can be split into four components: land use, transport, temporal, and individual (Geurs and Van Wee, 2004). For the purpose of this research, the operational definition of **accessibility** focuses mainly on the **transportation** component. It compares car-based travel to public transit travel with respect to journey time. **Land use** is simplified to only consider a few key origins and destinations representative of average commutes. Only weekday morning rush hours are taken into account.[3]

The **Trip Anatomy** framework describes the different components that constitute the journey time. A trip is the addition of pre-trip planning time, access-walking time, mode-specific wait time, riding time, possibly an interchange walking time and wait, and finally egress-walking[4] time. Studies have shown that the choice of mode depends, in order of significance, on the number of transfers, riding (or in-vehicle travel) time, total walking time, and initial waiting time (Chakour et al, 2012). Each additional transfer multiplies the initial waiting time and increases the risk of further delays due to not finding a seat. This is referred to as the *transfer penalty* and increases passenger disutility dramatically (Garcia-Martinez et al. 2018).

The **Journey Gap** is the normalized difference in time between using public transit and taking a private car. It is a powerful predictor of a user's mode of choice, assuming they possess the financial ability to choose between the two modes. A journey gap of 100% means that taking transit takes the same time as taking a private car; higher figures indicate comparatively longer trips by transit. In order for transit to compete successfully with private cars, the Journey Gap must be reduced to a minimum or reduced below 100%. In an ideal city, public transit is of very high quality and faster than car use. Most importantly, it is important to recognize that poorer residents of the city do not own cars. Thus, comparing travel times across different modes also reveals disparity between different socioeconomic groups (Campbell et al. 2019). The difficulties and long travel times of those who do not have access to a car or sometimes even transit come to light (Shalabi, 2018). Therefore, a high Journey Gap highlights unequal access to opportunity.

2.2. Data

Transit connections are computed using the Open-Trip-Planner (OTP) journey-planning software, and are based on unique data created by *Transport for Cairo (TfC)*[5] as part of the Digital Cairo project[6]. The data was then processed into the General Transit Feed Specification (GTFS), the industry standard for sharing transit information, which includes estimated waiting, departure, and transit times from each stop, and describes transfer points between different services.[7]

2.3. Methodology: Accessibility Analysis of Movement within NDCs, Between NDCs and to Inner-City Cairo

To put the Journey Gap method to practice, this study focuses mainly on Western NDCs. In particular, the study focuses on El-Sheikh Zayed City as a case study for analyzing movement within NDCs. El-Sheikh Zayed City was chosen because of its relatively small size, its monocentric internal network where all services start at a main supermarket called Hyper One, and its clear borders where all services end within NDC borders. Since it is only connected to inner city Cairo through three corridors, the number of issues that may arise in analyzing NDC

3 More details about the limitations can be found in Appendix A.

4 Access and egress are terms commonly used to denote walking time to (access) and from (egress) transit stations. Total walking time is adding access, egress and interchange walking times to each other.

5 Transport for Cairo (TfC) L.L.P. is an Egyptian action research lab which aims to reimagine existing transport networks to improve accessibility. It maps Cairo's formal and informal transit networks to improve planning provide passenger information.

6 Digital Cairo was a collaborative effort of Transport for Cairo, Takween for Integrated Community Development and Digital Matatus to create this data funded by ExpoLive 2020.

7 The data is published under an open license and can be downloaded at http://transportforcairo.com/data/.

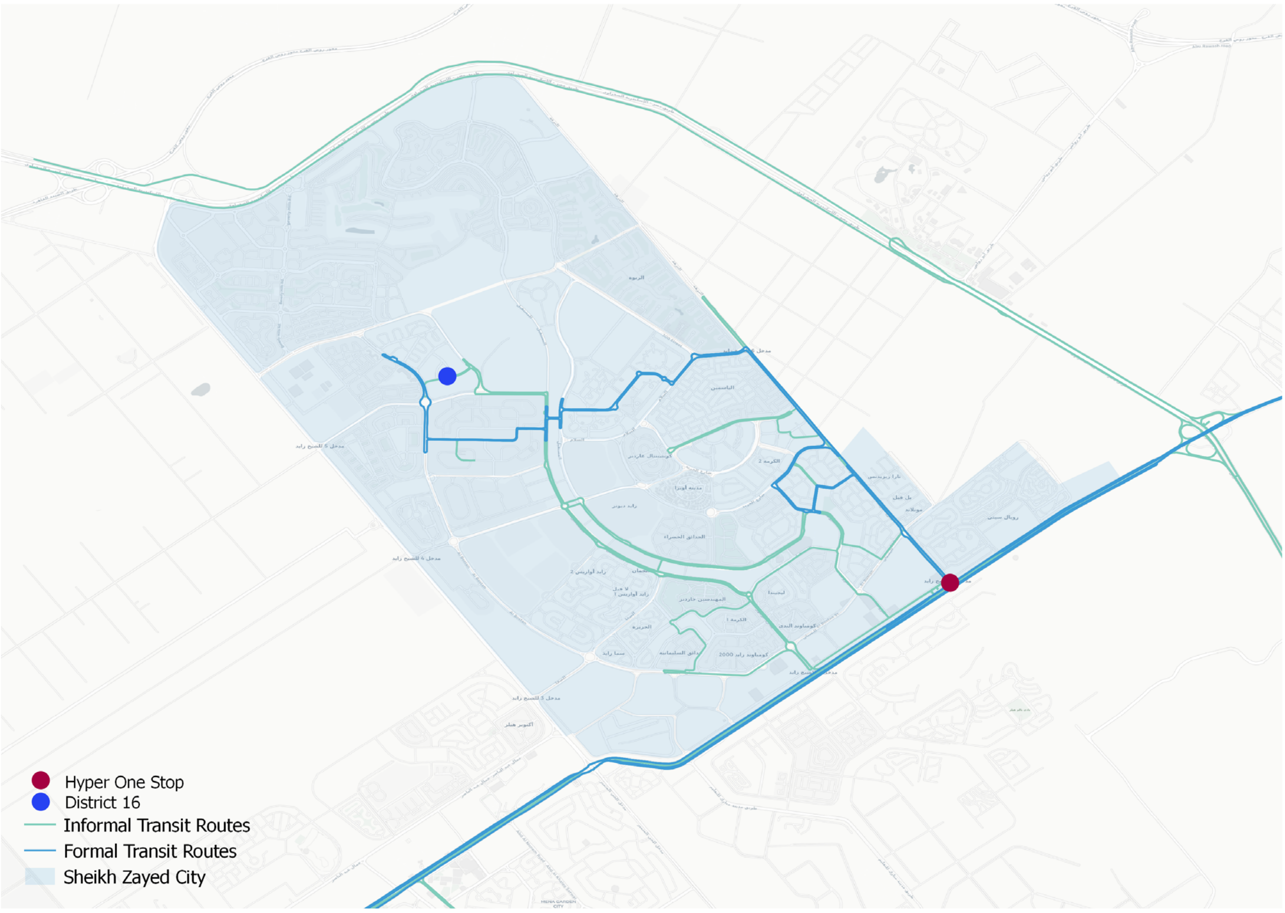

FIGURE 1 Map of El-Sheik Zayed City Showing Formal and Informal Transit Routes

to inner city itineraries are controlled. Furthermore, El-Sheikh Zayed City presents an interesting example, because currently there are two major and separate transport hubs. The first minibus hub at Hyper One is located on the fringes of the city, facing 26th of July El-Mehwar corridor and connecting it with multiple express[8] inter-city services to Sixth of October City and inner city Cairo. The second is a formal hub located in District 16, almost in the center of the NDC, and frequented by three formal local bus lines, and a single minibus route connecting it with Hyper One. In effect, the formal sector and the informal minibus sector are competing for passengers.

The analysis begins with a map of the district. Figure 2 presents a visualization for the methodological steps used to compute metrics over the administrative internal borders of El-Sheikh Zayed. For each area, we determine an origin point corresponding to the area centroids (Figure 2B). For each origin (Figure 2C), we compute travel times for walking, using a private car, and utilizing the transit network (formal or paratransit services) (Figure 2H / 2I) to each potential destination. The results are grouped in a *Travel Time Matrix*.

Private Car times are collected using the Google Maps distance matrix engine. The Application Programming Interface (API) provides the shortest driving distances using the road network. Driving times are queried on multiple occasions without congestion, and with average historic traffic congestion for 10:00 am (morning peak), 2:00 pm (midday) and 7:00 pm (evening peak) on a weekday, representing regular weekday commuting traffic. To simplify this analysis, we focused on the morning peak driving time.[9]

8 Local services mean serving all stops which are closely spaced, normally stopping every 300 m. Rapid services means serving regular but widely spaced stops every 800 m, generally around the beginning and end rather than a continuous area along the whole line. Express services means serving a long nonstop segment to the final destination.

9 More details are available in the limitation section (Appendix A).

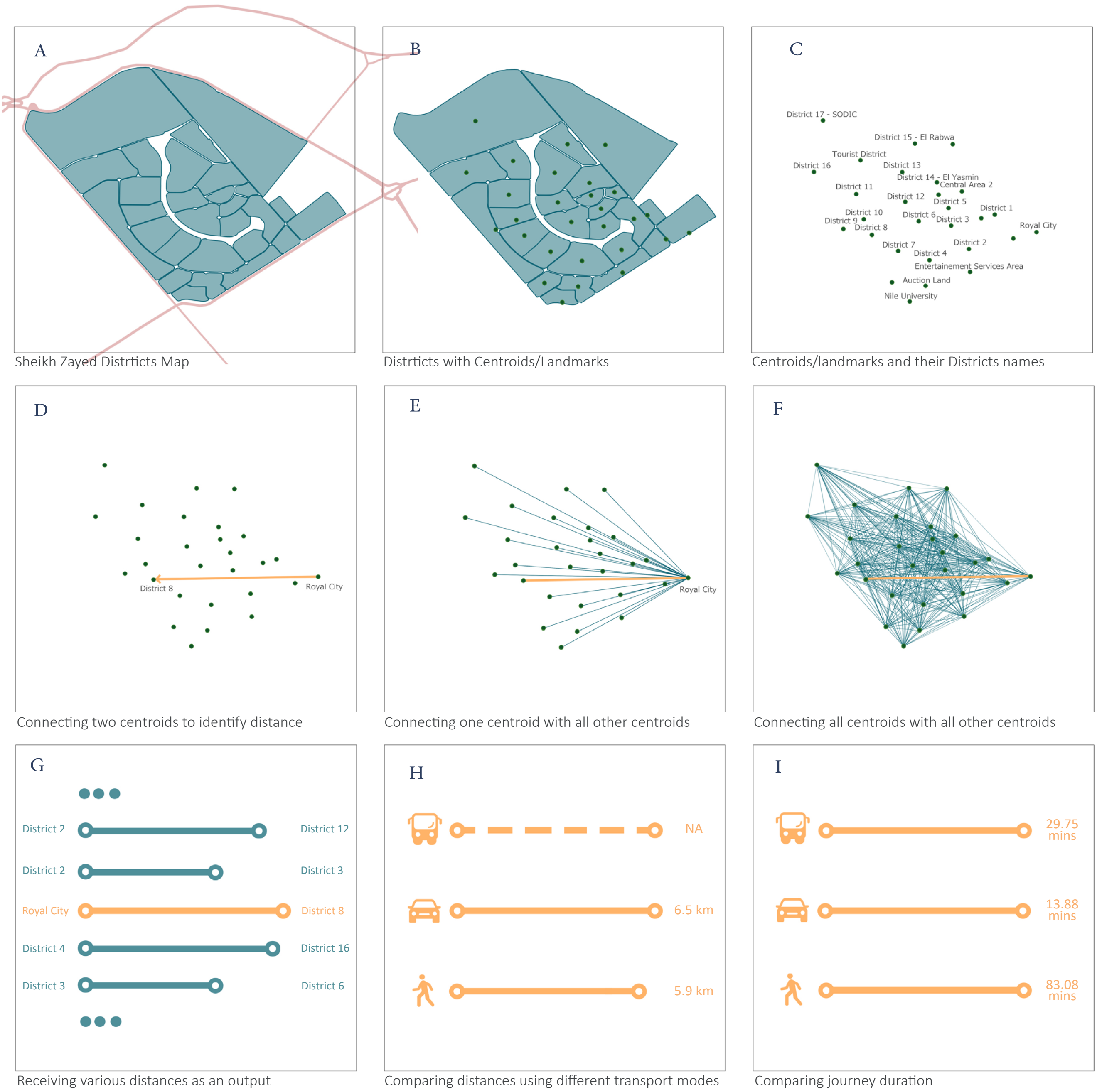

FIGURE 2 Visualization of Travel Time Matrix Computation Steps

3. Results: How Do NDCs Fare?

In order to understand the challenges of building an efficient transportation system in an NDC, we investigated the accessibility within El-Sheikh Zayed and from El-Sheikh Zayed City and Sixth of October City to main hubs within the Greater Cairo Region. The analysis of all possible origin-destination (O-D) pairs clearly reveals unsurprisingly that areas located close to the hubs and on the routes connecting them have the best journey times, while other neighborhoods exhibit lower potential mobility.

3.1. Accessibility Analysis of Movement Within El-Sheikh Zayed Using Three Typical Sample Modes: Walk, Transit, and/or Private Cars

To elaborate on the differences between the three modes, we give a hypothetical example of a 17-year-old girl named “Farida,” with no driving license, who is able to walk and has the ability to choose between modes. Farida lives in the east of El-Sheikh Zayed City (in point A), which is directly adjacent to El-Mehwar Highway. The area has the best connectivity to the road network compared to any other district. Thus, it is a best-case scenario in terms of accessibility for someone living in this NDC.

Going to point B in District 8 area in the west of the city, Farida has multiple options:

- Walking: The distance of 5.9km between point A and B is a long 83-minute-walk. Proximity to the El-Mehwar Highway and the vast open spaces of El-Sheikh Zayed City also make walking unpleasant and unsafe.
- Public Transportation: Assuming she has the means and feels comfortable, Farida could also access the public transport network. However, since there is no direct service to point B, she must get multiple connections to her destination. The fastest potential itinerary takes 30 minutes, including waiting for less than five minutes for changing between the minibus services, and walking 500 m to her destination. The combined cost of fares rarely exceeds EGP 7.
- Private Car: Since Farida has not yet reached the legal driving age, she can use ride-hailing services (i.e., Careem, Uber) for they are available, reliable, and safe. The trip usually takes 19 minutes, including five minutes for the service to arrive. Fares range between EGP 25 and EGP 32, excluding surge pricing. This is about four times the cost of transit.

However, Farida's daily routine might include more activities beyond her moving from point A to point B. Figure 4 gives an example of the estimated time that Farida might take going to school or to the supermarket using the different transport modes.

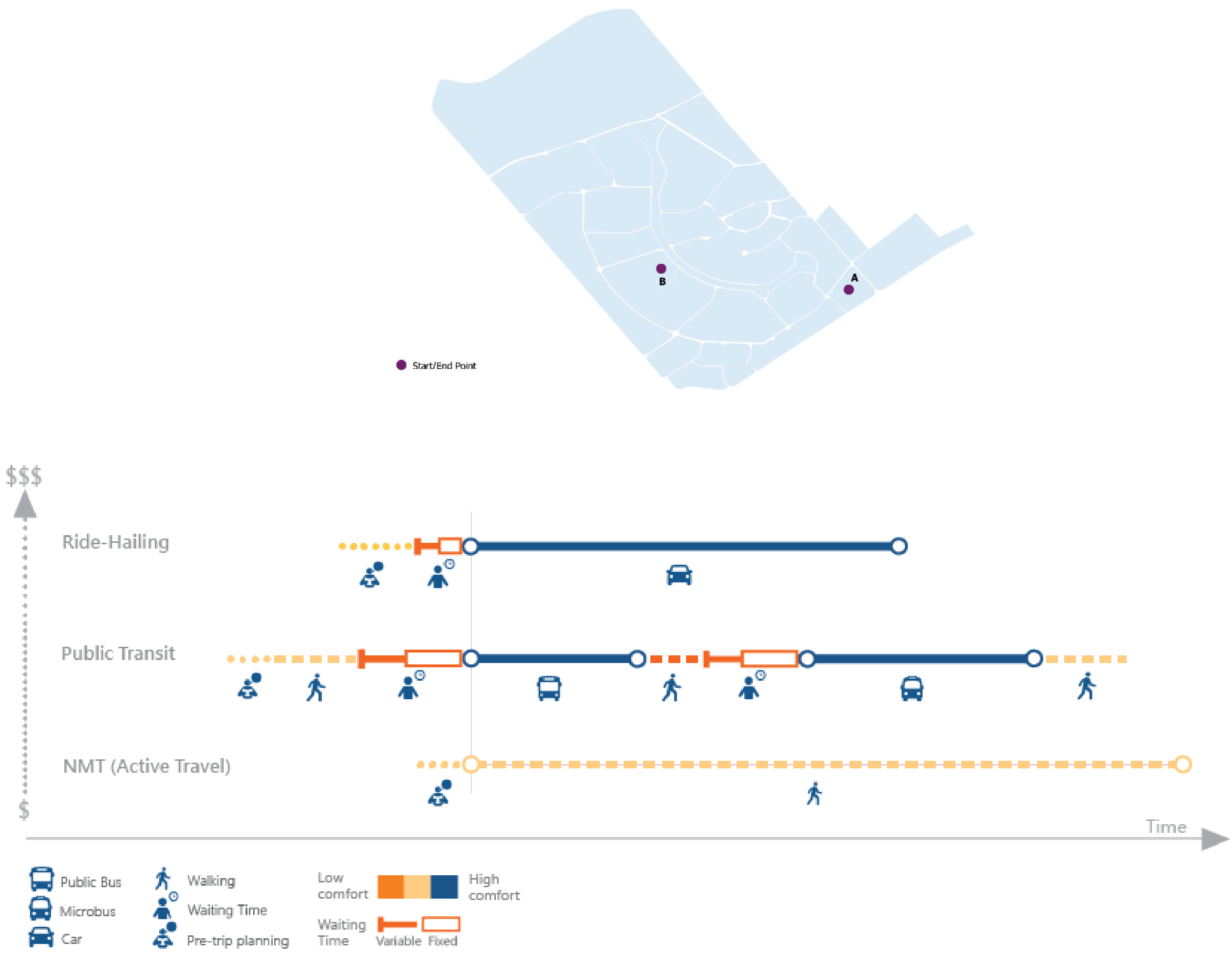

FIGURE 3 (Above) Locations of Start and End for Trip in El-Sheikh Zayed City. (Below) Graph of Expense vs. Time for Three Alternatives of Transport Mode and Their Segments.

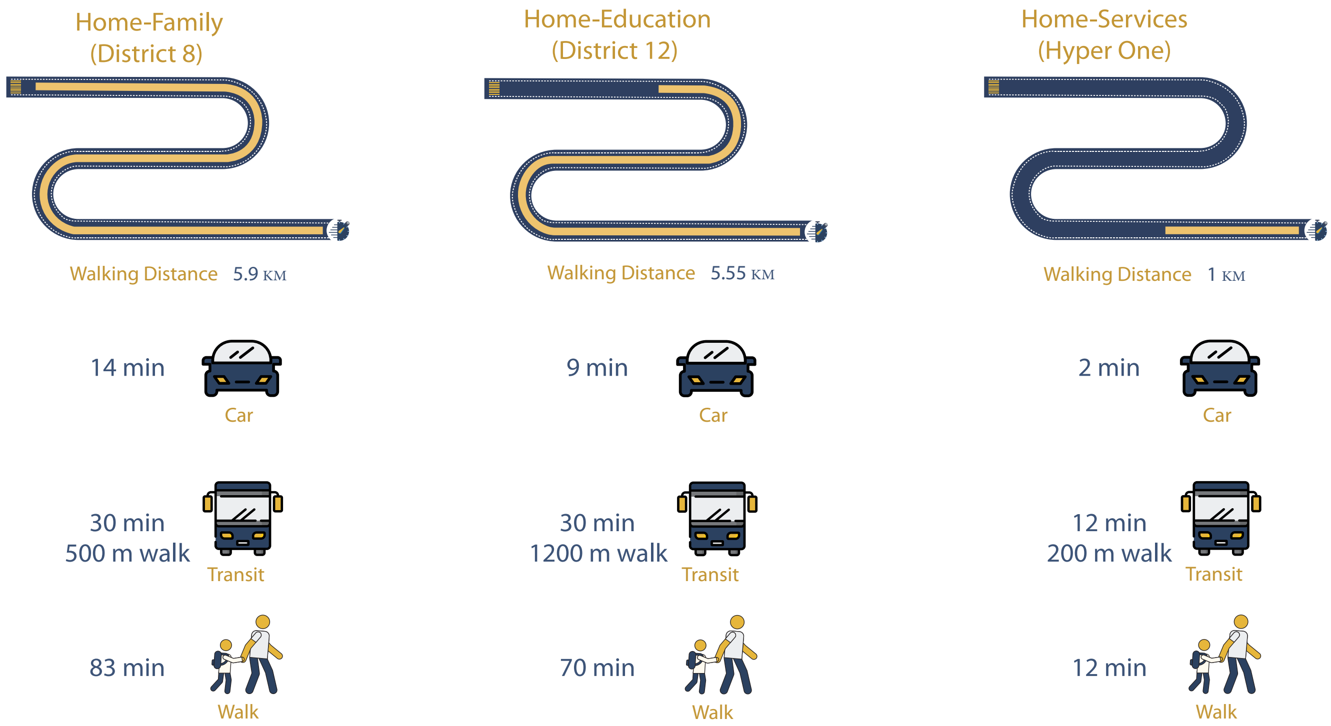

FIGURE 4 Route Lengths and Travel Times for Sample Itineraries from Point A

Figure 4 shows that the average walking time to all destinations within El-Sheikh Zayed City that Farida might take is 66 minutes. The existing public transport network dominated by Suzuki vans will take her to 23 out of 27 areas within El-Sheikh Zayed City, with an average travel time of 28 minutes. However, she will need to walk an average of 850 m to access the closest minibus stop and to walk from her minibus drop-offs to her potential final destinations. Although most destinations are directly accessible through CTA buses coming from downtown Cairo, waiting for the next bus increases the total travel time. On the contrary, it takes an average of 10 minutes to reach a destination anywhere within the city using a car.

The Potential Mobility Index (PMI) is an indicator developed by Martens (2017) that serves as an assessment and benchmarking tool for the quality of a network.

For this particular example, we computed two Potential Mobility Index (PMI) scores for each origin to all potential destinations in El-Sheikh Zayed City. Both scores calculate the aerial bird speed in km/h for travelling on the road network, first by private car and then using transit.

Point A has the highest PMI score for private cars in all of El-Sheikh Zayed at 26km/h. It is within a relatively short distance of El-Sheikh Zayed's largest transit hub at Hyper One, causing the relatively good performance of transit (8.6km/h) in that direction as well. In returning to Point A on El-Mehwar Highway both private cars and public transport vehicles face a lengthy detour driving towards the closest U-turn; rapidly increasing driving distance and time. Consequently, the PMI score for returning to point A by car drops to 14km/h.

On average, trips by car require an additional 3 minutes of highway driving time. Walking remains almost unaffected. Trips by public transit to Point A require an average of 39 minutes, while increasing average walking distances to 1.7km.

Expanding the analysis (Figure 2E above), all possible origins and destination pairs were examined through building a matrix of every possible travel itinerary within the geographic area of El-Sheikh Zayed City. For each origin-destination pair, the

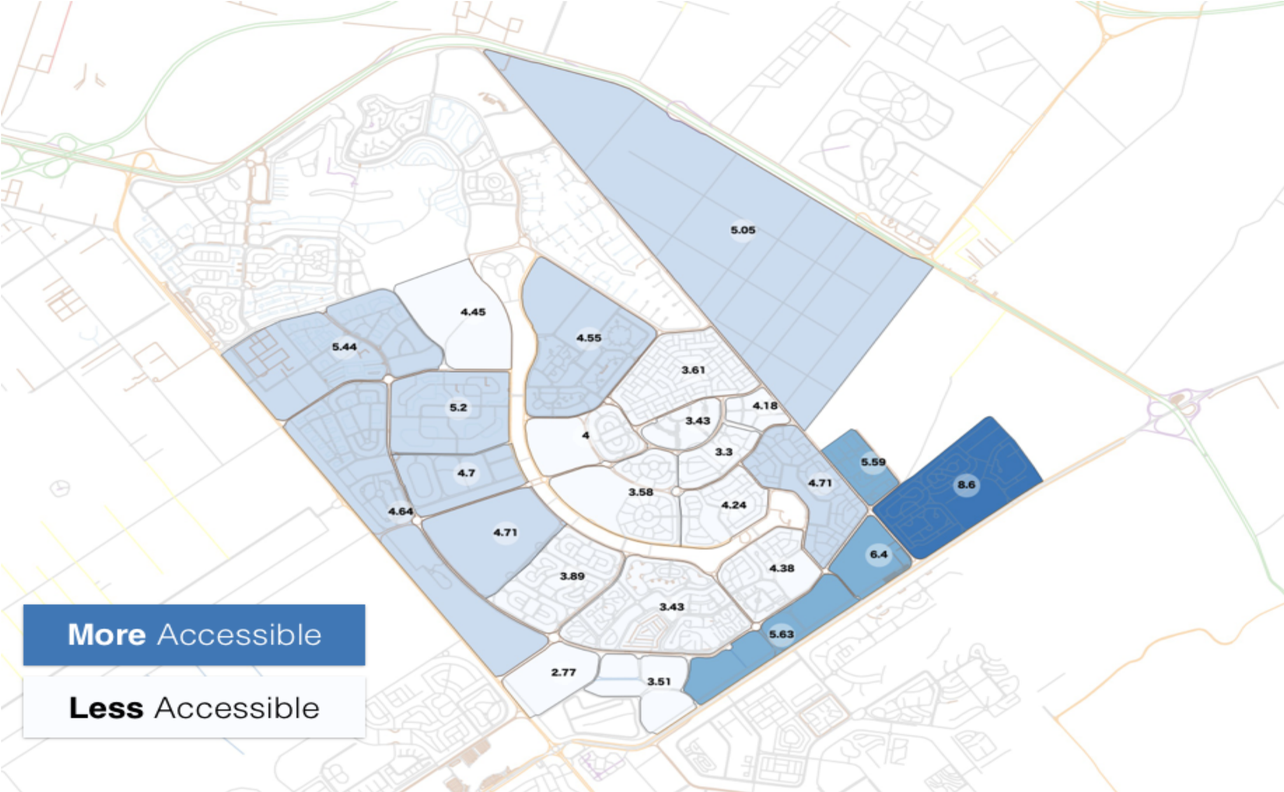

FIGURE 5 Potential Mobility Index. Speed in km/h of Travel in All Directions Using Public Transport

travel times for walking,[10] private car, and public transit were computed.

The same accessibility analysis was computed between all neighborhoods of El-Sheikh Zayed City and all neighborhoods of the adjacent Sixth of October City. Such analysis gives an indication about the effectiveness and efficiency of commuting between Sixth of October City and El-Sheikh Zayed City. It also helps highlight the difference that owning a car can make.

By reviewing averages, it is apparent that walking is not a realistic option due to the sheer geographic size of the territory in question, where the average walking distance is 13km. While transit connects 40% of all potential itineraries, more than half of all origin-destination combinations require walking more than 2km, while the conventional accepted total walking distance is just 1km[11]. Remarkably, trips that require less than 2km walking to and from stops have an average travel time of 66 minutes. Only 11% of trips contain no transfers, 39% include one transfer, and 48% require two transfers, implying a fragmented feeder-trunk-distributor transit system. On the other hand, using a private car takes an average 24 minutes, which is almost three times faster than transit. These numbers imply that moving in and between NDCs is highly dependent on having a private motorized vehicle in light of the number of transfers and walking time; otherwise, travel between these two communities is a burden in terms of time and cost. For this reason, only those who have easy access to a car as well as those who have consigned themselves to long trip times in transit move to NDCs. *Consequently, a competitive and affordable public transport system will need to adopt an efficient network logic in planning to connect the cities for transit users.*

10 Walking times were retrieved from the Open-Trip-Planner journey-planning software and rely on the Open Street Maps (OSM) network of main roads and streets. Moreover, crossability of the roads was taken into account when planning the routes accordingly.

11 2km is an exaggeration of the conventional accepted walking distance of 1km. A walking distance of 1km assumes up to 500 m access walking distance at the origin stop, followed by an additional up to 500 m egress walking distance at the destination. 500 m is defined as 'sensible' in the European HiTrans guide (Nielsen et al. 2005) and as a standard in transport planning; 500 m also forms the basis of SDG 11.2.

3.2. Accessibility Analysis of Movement from El-Sheikh Zayed City and Sixth of October City to Main Hubs within the Greater Cairo Region

Analyzing travel from El-Sheikh Zayed City and Sixth of October City to inner city Cairo gives a system-level overview of the transit network quality and a comparison with private cars. Hence, we explored seven potential destinations within inner city Cairo, all of them are main transport hubs. These hubs are Attaba, Ramses, Abbassiya, Abdel-Moneim Riyad, Lebanon Square, Giza Square and El-Moneeb.[12]

Table 1 and Table 2 compare the average travel times using public transport and private car for Sixth of October and El-Sheikh Zayed, respectively. It is evident that transit connections between western NDCs and inner city Cairo exist. 78.6% of all areas examined within El-Sheikh Zayed City and 64.7% of all origins studied within Sixth of October City had a transit connection to inner city with two transfers or less, and a total walking distance of less than 2km. Moreover, the average walking distance per itinerary for Sixth of October and El-Sheikh Zayed is 1500 m and 1060 m, respectively. However, as can be gleaned from the tables, total trip time for private cars are always faster than transit.

Mode	To / Data Item	Abbassiya	Abdel Moneim Riyad	Attaba	El-Moneeb - Metro	Giza Square – Metro	Lebanon Square	Ramses - Metro
Private Car *Time in min, total trip duration including walking, excluding parking*	mean	73.8	59.9	70.4	42.6	45.6	45.2	75.8
	min	51.4	40.7	50.5	21.8	25.4	26.3	56.1
	median	74.5	61.2	71.7	43.5	46.5	46	76.9
	max	87.3	71.2	82.2	57	60	56.7	89.3
	sd	8.8	8.1	8.2	8.9	8.7	8	8.3
Journey Gap ΔTravel Time of Transit to Private Car		152.71%	143.41%	128.69%	233.10%	203.51%	147.57%	122.30%
Transit *Time in min, total trip duration including walking, waiting, transfers*	mean	112.7	85.9	90.6	99.3	92.8	66.7	92.7
	min	73.3	45.6	49.5	57.9	51.8	26.5	50.9
	median	112.9	85.8	89.2	99.8	92.9	66.4	94.2
	max	137.1	116.3	114.2	121.6	116.4	99.8	115.6
	sd	14.5	15.8	13.3	15.5	14.8	15.6	13.5
Transit *Walking Distance in min*	mean	1268	1244	1348	2129	1951	1225	1450
	min	357	193	397	905	890	193	639
	median	1194	1138	1322	2042	1888	1120	1400
	max	2108	2435	3011	3199	3504	3146	2962
	sd	523	594	567	643	713	666	528
Transit Number Transfers	mean	1.61	0.68	1.82	1.57	0.96	0.79	1.64

TABLE 1 Travel Times from Sixth of October to Inner-City Cairo (in minutes)[13]

12 We compute the travel times averaged between all origins within Sixth of October City and the aforementioned seven destinations within Cairo. We repeat the computations for all origins within El-Sheikh Zayed City.

13 Travel time for using a private car and for taking transit, assuming travel at 10:00am on a typical weekday. For transit, 28 potential itineraries (out of 224 total possible) are not possible, as no connection exists. -These values have been stripped before the computations. All OD pairs with more than 2km walking or more than two transfers were stripped before all computations.

The gap in journey times between private cars and public transit averages an additional 90% extra time for Sixth of October City and an additional 102% extra time for El-Sheikh Zayed City. Such a situation discourages the majority of individuals from taking public transportation and forces them to rely heavily on private cars, an additional cost to the cost of housing in these NDC. This calls for a better public transport network designed for accessibility.

Mode	To / Data Item	Ab-basseya	Abdel Moneim Riyad	Attaba	El-Moneeb - Metro	Giza Square - Metro	Lebanon Square	Ramses – Metro
Private Car	mean	67	53	63.6	34.9	37.9	38.4	69
	min	58.5	46.7	56.8	27.7	30.9	32.1	62.6
	median	67.7	53.4	64.1	35.3	38.3	38.7	69.4
	max	75.4	59.8	70.4	42.6	45.6	44.8	75.7
	sd	3.9	3.1	3.2	3.7	3.7	3.1	3.1
Journey Gap ΔTravel Time of Transit to Private Car		152%	140%	124%	252%	215%	139%	117%
Transit ,Time in min total trip duration including walking, waiting, transfers	mean	101.6	74.4	78.9	87.8	81.5	53.2	80.6
	min	77.7	52	57.5	65.8	60.7	30.6	58.9
	median	104.2	75.8	80.8	90.3	84	55.8	82.7
	max	125.1	98.5	102.5	109.5	105.7	76.3	103.9
	sd	12.6	12.2	10.3	10.4	10.7	11.5	10.3
Transit Walking Distance in min	mean	1227	1257	992	1209	1501	992	955
	min	189	376	359	518	723	25	328
	median	1121	1219	840	1157	1400	880	857
	max	2391	2208	2193	3061	2580	2208	2145
	sd	651	489	449	572	432	626	450
Transit Number Transfers	mean	0.75	0.54	1.96	1.96	1.04	0.92	1.88

TABLE 2 Average Travel Times from El-Sheikh Zayed to Inner-City Cairo (in minutes)[14]

14 Travel time for using a private car and for taking transit, assuming travel at 10:00am on a typical weekday. For transit, 28 potential itineraries (out of 224 total possible) are not possible, as no connection exists. These values have been stripped before the computations.

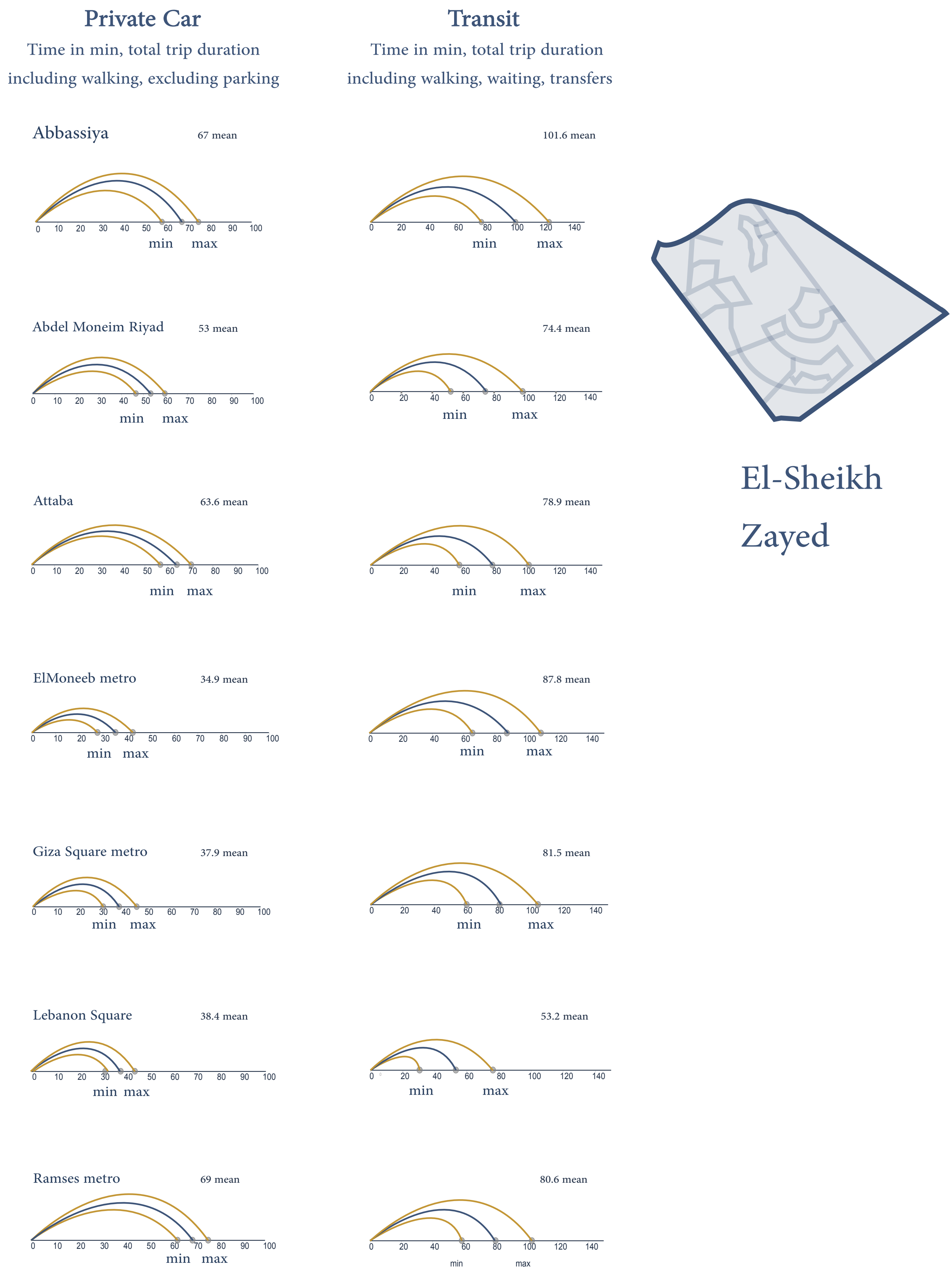

FIGURE 6 Accessibility Analysis of Movement from El-Sheikh Zayed City to Main Hubs within the Greater Cairo Region

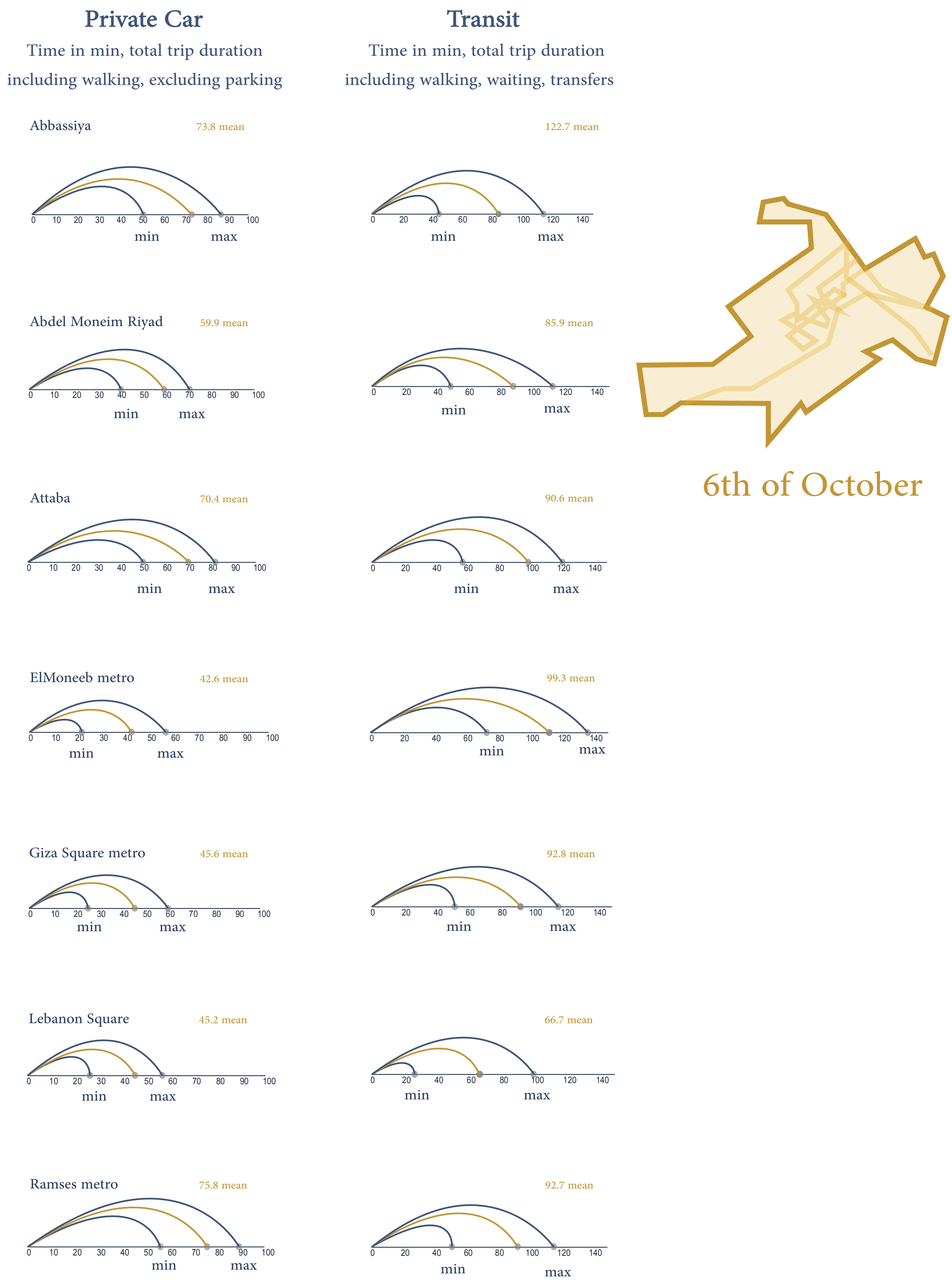

FIGURE 7 Accessibility Analysis of Movement from Sixth of October City to Main Hubs within the Greater Cairo Region

Upon examining dominant operation modes within the transport corridors under study, Figure 8 shows the distribution of the number of transfers of examined origin-destination pairs. Since almost 90% of itineraries require a transfer at one of the transport hubs within NDCs, a traveler will less likely choose transit over a private car.

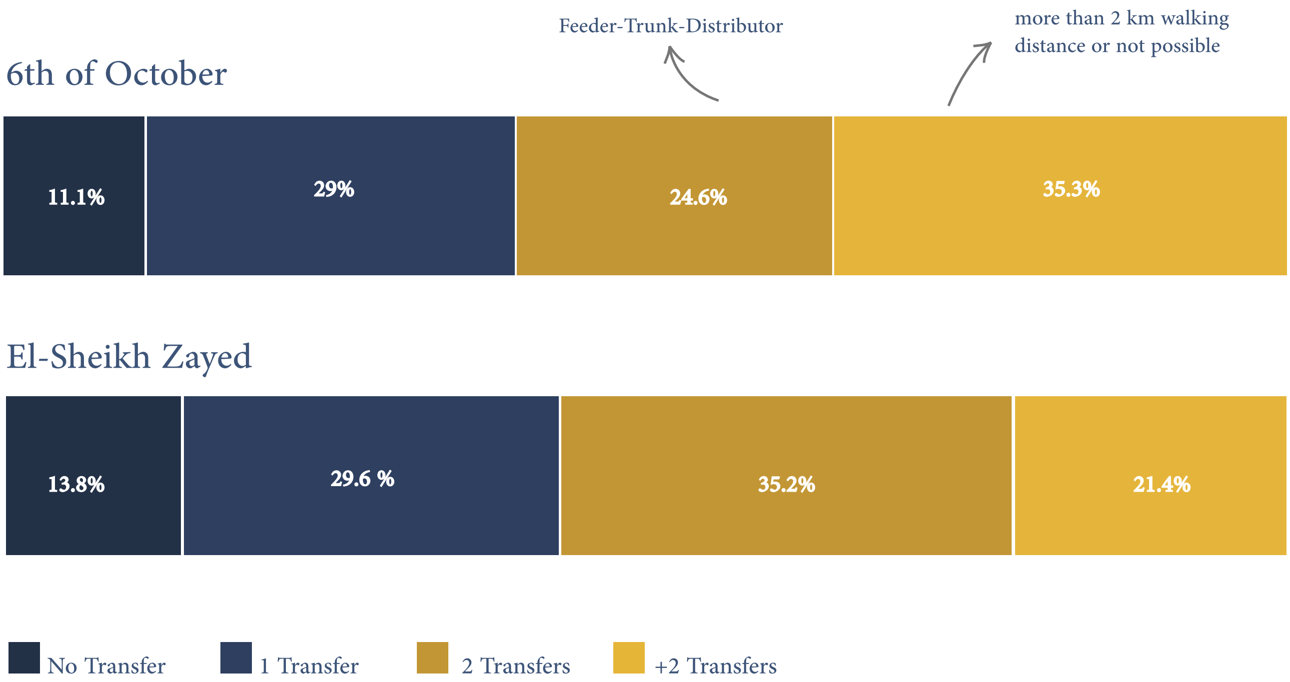

FIGURE 8 Percentage of O-D Pairs that have 0, 1, 2 and More than 2 Number of Transfers for Trips Connecting Western NDCs with Inner-City Cairo

The combination of higher overall trip time, including waiting time, as well as the frequent transfers result in a very unattractive commute experience for residents of NDCs on their way to inner-city Cairo. This grim reality is not a fait-accompli. These NDCs are new and still growing. Consequently, the next sections present some successful examples of transportation reform and Egypt can learn from them to create its own approach to improving access, mobility and hence the attractiveness and potential of the NDCs.

4. Policy Options and Context

This section presents successful urban mobility policies from a variety of cities. It describes the situation and mitigation measures taken in Los Angeles, London, Paris as well as some efforts at institutional reform from Bogota, Dakar and Lagos. It also presents the Enable-Avoid-Shift-Improve (EASI) framework, which is a valuable tool for thinking about how to improve the quality of life in cities.

London, Los Angeles, and Paris are some of the world's most economically dynamic and attractive cities. However, they face high levels of private motorization that cause serious problems of air pollution, congestion, crashes and particularly in the case of Los Angeles inefficient land-use patterns. A desire to improve livability and public health, along with a dedication towards reducing energy consumption and addressing climate change, led them all to adopt a number of transport policies relying on the "Avoid-Shift-Improve" framework (GIZ, 2013):

- Avoiding bad urban growth patterns that increase the need for transport and private cars,
- Shift transport modes towards active modes and public transit that reduce air pollution and improve public health,
- Improve the system by reducing travel times and better modes.

	Avoid (Problem)	Shift (Vision)	Improve (Method)
London	• Ongoing population growth. • Most of the future employment growth in Central London. • New Housing construction around massive new transit infrastructure investments, such as Crossrail I and Crossrail II.	• Halving private car use, taxi and ride hailing by 2041 (compared with 2015). • Increasing walking, cycling and public transport to reach 80% of the modal share by 2041.	• Healthy Streets Approach to reallocating road space away from private cars and towards active travel. (Mayor of London, 2018; Transport for London, 2017)
Los Angeles	• One of the most sprawling cities worldwide. • Very high dependence on private cars and solo travel • Highest traffic congestion in the United States. (McCoy, 2018)	• Double the percentage usage of transportation modes other than solo driving between 2018 and 2028. (LA Metro, 2018)	• Identifying and improving mobility gaps in the transit network. • Direct manipulation of the trip anatomy. • Ensuring transit within a 10-minute walk or cycle from home • Reducing wait times to 15 minutes for all trips all day. • Reducing trip times and providing protection to transit from road congestion.

	Avoid (Problem)	Shift (Vision)	Improve (Method)
Paris	• Very low car ownership/ usage within the city of Paris. • Very high car ownership / usage within the suburbs of Paris/wider Ile-de-france region. • Direct Transit connections between the suburbs of Paris are almost non-existent.	• Reducing suburb-to-suburb commutes and drive economic, social and institutional development of the Paris Metropolitan Area. • Lowering car usage within the Paris Metropolitan Area.	• Reduction of travel time and trip durations through Grand Paris Express, Europe's largest public transit project to new lines, longer spacing between stops and the fastest commercial speeds for any metro. • Metropolitan level governance through the creation of the Metropole du Grand Paris, and the Sociéte du Grand Paris to work across metropolitan level stakeholder. (Enright, Theresa Erin. 2012)

TABLE 3 Analysis for London, Los Angeles and Paris Policies in Light of the "Avoid-Shift-Improve" Framework

These dynamic and livable cities all share *enabling* regulatory and governance frameworks. There are effective public transport authorities that work within regional-level metropolitan governance structures. Furthermore, there is a publicly stated policy objective to reduce the gap in journey times between private cars and transit by identifying and improving mobility gaps in the transit network. In addition, they work on encouraging active transport modes and reducing air pollution.

4.1. Urban Mobility Policies of the World's Rapidly Growing Cities

One advantage of cities like Cairo from the point of view of the EASI framework is that the majority depend on walking and public transport services more than cars. This means that a major opportunity exists to reduce pollution and congestion and create a livable, healthy city through developing transit network improvements serving the majority. However, some of the challenges to achieving this include harmonizing and streamlining governance frameworks, as well as the rapid pace of urbanization.

4.1.1. ***EASI*** - Enable-Avoid-Shift-Improve: a Conceptual Framework[15]

The Enable-Avoid-Shift-Improve (EASI) conceptual framework is a global standard for transforming the transport sector for better urban living (Stucki, 2015).

The *Enable* pillar focuses on the institutions and decision-making processes that deal with the complexity of urban transport systems and its multiple actors. Its recommendations cut across geographic scales. A **national urban transport strategy** is one key intervention. Enabling a metropolitan **Public Transport Authority**, empowered with adequate human and financial resources to plan and coordinate activities is essential. A successful example for this pillar is the Lagos Metropolitan Area Transport Authority (LAMATA) reform process in **Lagos, Nigeria**. In 2003, the Nigerian government established LAMATA to create a formal bus system through private investment and public regulation. It contracted operators, and managed existing buses operating in that same corridor as the new Bus-Rapid Transit (BRT) system through legal instruments. The BRT

15 More information about the case studies in this section can be found in the background paper.

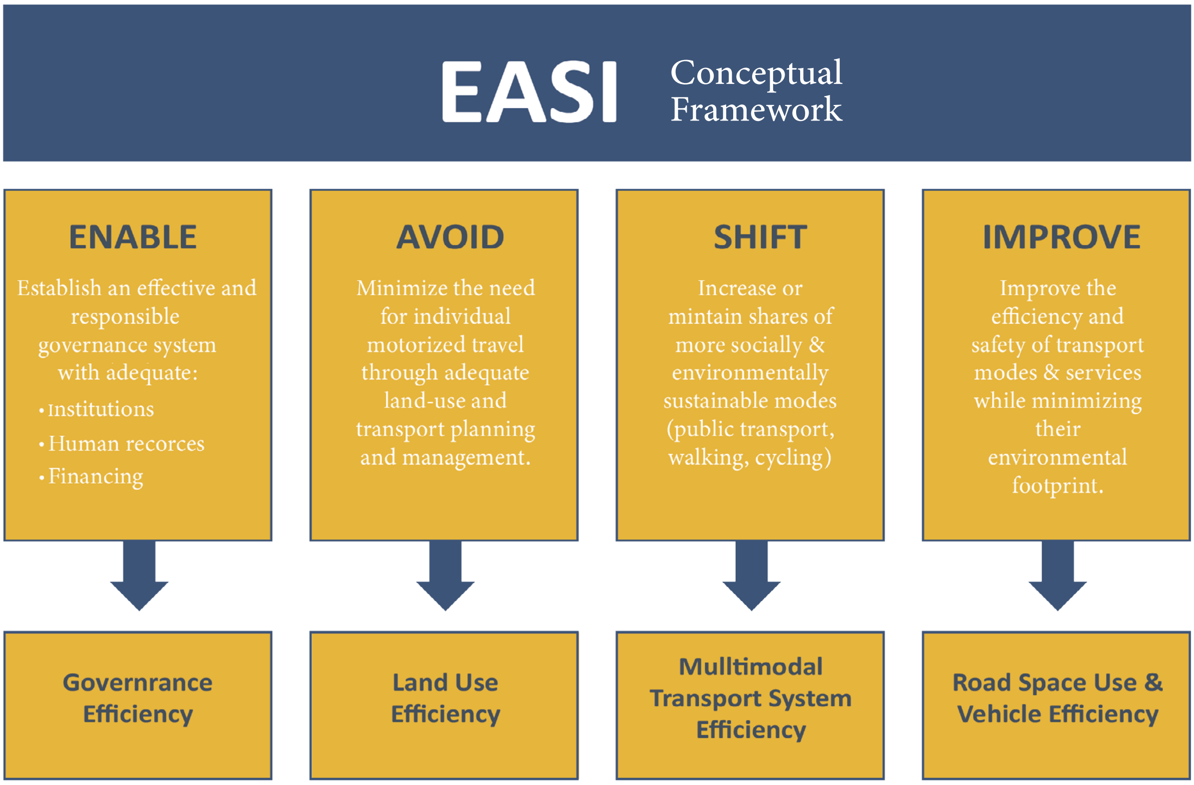

FIGURE 9 Easi, a Conceptual Framework for Steering Public Action Towards Sustainable Mobility in African Urban Areas

was met with eager ridership, and the operator more than doubled the number of buses on the corridor.

On the other hand, the *Avoid* pillar discourages single-occupancy cars for they are neither economically nor environmentally sustainable given the high levels of pollution causing a heavy and costly public health burden. This pillar also mitigates the inequities in the transport system. Recommendations for this pillar include:

- Planning urban forms that are mixed, dense, polycentric and pedestrian friendly. High density residences ensure a critical mass of riders in more spread out and complex patterns across the city which helps support a financially viable public transport service. Polycentric development ensures that not all commuters travel in the same direction at the same times causing unavoidable crowding during rush hours. Finally, pedestrian friendly urban forms encourage people to walk and use more transit instead of hurriedly getting into cars to avoid the chaotic streetscape, which is good for public health and the environment as well as savings (cars are expensive).
- Triggering financing mechanisms, such as land value capture, which increase accessibility for residents. When a new transportation service is created, real estate values along the length of the service most often increase significantly. The government should capitalize on this dynamic through negotiating with developers to help finance transport in exchange for the land value.
- Targeted deployment of transport infrastructure to guide urbanization followed by a strengthened land management regime. Encouraging residents to move to a newly built area can be enhanced by improving connecting with the central city and economic opportunities through rail or rapid bus.

The **South African** experience in reforming public transport through the introduction of BRT is a cautionary tale. The expected benefits included improving operational efficiencies due to congestion protection for buses, and electronic fare collection, allowing lower public subsidies while giving passengers greater choice and better service. In reality, only two cities, Johannesburg and Cape Town, were able to install a first set of BRT corridors. Negotiating with existing operators and cost-overruns revealed operational costs to be 25-40% higher over the previous system compared to the original estimates. Ridership revenues were lower than anticipated resulting in a long-term operational funding shortfall that is affecting South African cities.

Original revenue estimates were based on assumptions derived from BRT successes in Latin America. History explains the South African context: large low-density residential areas on the periphery of cities contributed to a scenario all cities aim to avoid (Munoz-Raskin and Scorcia, 2017, 2018). This pattern of land use results in quite long individual trips, very low seat turnover, and excessively concentrated demand at peak-times. The South African paratransit sector proved far more efficient at providing long-distance one-seat rides quickly adapted to market needs and the existing urban form; and car ownership remains desirable and increasing, while the BRT struggles.

The *Shift pillar* focuses on protecting and furthering the advantages of walking and using public transit. It is centered around the idea of multimodality where diverse modes of transport work best for different portions of each trip and at different geographic areas. Planning for multi-modality hinges on understanding demand, enhancing the pedestrian and cycling infrastructure since they affect every simple trip using public transit and designing hierarchical and integrated urban transport systems. A trip can start with a feeder service operated by minibuses, continue on a high capacity high quality mass transit backbone such as the Metro and end with a short walk. Bogota's experience in Colombia presents the most successful full implementation of a Bus Rapid Transit (BRT) system took place and ignited the world's eager applications of it. It consists of a system of segregated trunk corridor routes. A system of feeder services operating in mixed traffic acts to transport passengers to and from BRT stations, expanding the system catchment area. The prerequisite step for *Transmilenio's* success was Bogota's public space projects. Parking on sidewalks was banned, car-free days were instituted, bike lanes were constructed, and anti-littering campaigns were enforced. A plate-numbering system kept 40% of drivers off the road during rush hours. *Transmilenio* and the public space projects shifted Bogotas mode share away from private cars towards non-motorized or "active" transport and public transport (Stucki, 2015).

Finally, the *Improving* pillar entails enhancing the diverse components of the urban transport system: pedestrian and cycling infrastructure, as they affect every simple trip using public transit. Managing traffic flows and demand is a necessity for buses and paratransit to function well. Fuel efficiency standards need technical enforcement to be fair and environmentally friendly. Enhancing minibuses, which dominates service provision, is inevitable. Consolidation of operations, contracting based on performance criteria, the setting of tariffs conducive to full cost-recovery under a regime of supervision, incubating formal business and clever financing for vehicle renewal are all options available to policy makers. The paratransit minibus fleet-renewal program administered by Conseil Exécutif des Transports Urbains de Dakar (CETUD) in **Dakar, Senegal** sets a successful example for the *Improvement pillar*. Policymakers adopted a process consisting of three stages. The first step was *Registration* where the operators were brought into a system regulated by local government through cooperatives. Then, it established the route as the unit of regulation (as opposed to traditional models of the bus or the operator licensing); in this stage, there was an agreement with the members to occupy the most lucrative routes within Dakar in exchange for scrapping old vehicles, paying a deposit for new vehicles and the introducing tickets paid by users. Finally, *permits* that regulate and raise the quality through stimulating investments with long-term investment security were introduced.

5. Proposed Policies and Applications

Relying on the EASI framework, this section presents a package of suggestions to improve mobility and access, within Cairo's NDCs. It proposes policies that decrease journey times for public transport and walking. It envisions improving accessibility of services through better public transit and reducing the reliance on private vehicles.

The suggested policies are a mixture of national, metropolitan and local policies. While the current proposals, at the municipal level, are aimed at El-Sheikh Zayed City, they are generalizable in some form or modification to the other seven NDCs within the GCR, as well as a guide for the development of the New Administrative Capital. These should not be understood as recommendations for urban mobility and access within inner-city Cairo, given its different and complex nature, although some similarities in problems and potential approaches exist.

5.1. Clear Vision and Strategy

To achieve sustainable change in the domain of urban mobility and access, some enabling policies at the national scale must first be adopted. Aligning with the objectives and goals of the SDS 2030, there should be **a national sustainable urban transport strategy** developed under the auspices of the Ministry of Transportation, with active participation from all stakeholders. The strategy should act to set clear goals and guiding principles for urban mobility planning.

The national sustainable urban transport strategy should define an urban mobility framework that includes legislative, resourcing and technical dimensions and provide the needed policy framework. This process can be started through a task team that identifies key stakeholders for collaboration, and builds a practical timeline for needed urban mobility related legislation, policies and institutional setups. Key aspects of the strategy include support for public transport and active transport, localizing the EASI framework and activating public transport authorities (PTA) in metropolitan areas.

5.1.1. Modal Share as a National Objective

The strategy should detail a national objective that encourages shifting modal share away from private cars and towards a mix of public transit and non-motorized modes of travel. Shifting the modal share can be brought about by systematically altering the trip anatomy through a series of small steps that improve public transport and street layouts. These include creating a rationalized bus stop network optimized for reducing walking times and waiting time, improving pedestrian and cycling network, as well as public transport facilities (i.e., terminals and bus stops), dedicated right-of-way for public transport, optimized traffic lights and parking management. These small steps contribute to reducing the Journey Gap between private vehicles and public transport. The Journey Gap is negatively related to the Modal Share; the lower the Journey Gap, the higher the share of public transport and active modes. Improving the walking, cycling and public transport experience is a prerequisite for shifting people away from cars.

There also should be links between the effects of different urban mobility policies on other targets. For example, the construction of the New Administrative Capital based on current plans is likely to significantly increase total vehicle-miles travelled, and thus further enlarge the transport sectors already increasing contribution to pollution and CO_2 emissions. Both air pollution and carbon foot prints of different policy and planning alternatives need to be more carefully measured and mainstreamed into our sustainable urban mobility policies and planning. ***Shifting the modal share and reducing the journey gap also go hand-in-hand with planning urban forms that minimize capital and operating costs of***

transit infrastructure. For example, the entrance of Nile City University is located at the 26th of July El-Mehwar corridor. While this is preferential from a private-car perspective, it is detrimental to inclusion within an internal transit network for El-Sheikh Zayed, and for pedestrian or cycling access. A similar problem exists with gated compounds providing a single entrance and exit point, effectively choking pedestrian access. These urban forms were created with the explicit expectation of a private car for each individual. This planning style must be discouraged and supplanted by a strategy that encourages shared vehicles and faster flow of people, at least in places with higher density mixed-land use. Had these residences been denser and less gated, a higher number of riders could have enabled more financially viable services to operate more often.

However, for an effective targeting of the modal share, more information is required in terms of the current ratio of usage of private cars, of trips using collective transport (formal or paratransit) and active travel (walking and cycling).

5.1.2. Activate Public Transport Authorities (PTA) in Metropolitan Areas

In light of the current challenges, there should be public transport authorities (PTA) in metropolitan areas that work on planning, regulating and implementing improved urban mobility strategies. Each PTA would be tasked to develop an integrated sustainable urban transport plan (SUMP) at the city-level, which aims to achieve the overall national urban transport strategy. These plans identify city-level targets, capital and operational budgetary requirements, and potential financing sources and strategies. Learning from the experience of the Lagos Metropolitan Transport Authority (LAMATA)[16], there is a need for an aggressive headhunting process, to build and maintain the necessary human resources and technical capacity, followed by a medium-term financing strategy to create its own revenues.

16 More information about the LAMATA experience is available in the background paper.

PTAs should work on creating standardized bus stops for all kinds of transit services. Rationalizing bus stops is a quick, relatively affordable and highly effective way to reduce the Journey Gap, and improve the public transport experience. Rationalized bus stops increases the system's efficiency and reliability since it curbs excessive stopping and waiting time. Stops should be coordinated with traffic police to protect them from private vehicular traffic. The authority should provide dedicated stopping areas and right of way to protect transit from congestion, particularly at choke points. Cheap low-tech solutions and an inclusive design (signing, information, shade, and seating) should be adopted, increasing the attractiveness of the system (Lerner, 2014).

NDCs particularly provide a greenfield opportunity to charge licensing fees for private sector public transit service provision and develop NDC-level plans. As the PTA's capacity matures, it should start working with more local levels of urban mobility stakeholders, including NUCA and the individual City Authorities, such as the El-Sheikh Zayed Authority. **Each NDC should draft and update its own NDC-level urban mobility strategy.** Such strategies should publish actual and target modal shares in a regular fashion, and address particular steps to be taken to achieve them. The PTA should assume the coordination role of a participatory process for each city involving relevant stakeholders, and provide technical assistance. The **PTA is expected to collect and analyze modal share and public transport data on the metropolitan scale** to compute the Journey Gap. *It will then act as a single point of accountability for reducing the Journey Gap, and improving the public transport experience.*

With respect to El-Sheikh Zayed City Authority in particular, the PTA could **issue permits that regulate and raise the quality of service through a series of systematic steps**. First, the City Authority, in coordination with the PTA, should issue permits which establish the route as the unit of regulation (as opposed to traditional models of the bus or the operator licensing). Operators would still have complete commercial responsibility, and be subject to basic requirements in relation to issues such as vehicle safety, standards, environmental control, and stopping within any of the designated bus stops of the rationalized stop network enforced by the City Authority.

As the City Authority raises its technical and financial capacity regarding urban transport, it can start assuming some of the commercial risks and influence service features (fares, headways and quality, operating times) and develop ways to monitor the performance of the franchise. It could transfer fare box revenue collection to a central authority and contract operators on a gross contract model, where it determines and pays for vehicle kilometers of service rendered. Centralized fare collection could then start using a simple paper-based prepaid fare vouchers available from local vendors, and grow over time into an electronic system, allowing systematic data collection and real-time service changes. Different operators are then grouped under a common brand, in order to increase commuter trust. The newly insured service consistency improves ridership, as passengers gain more trust in a more reliable and high-quality system.

Regulating paratransit/mini-microbus basic service requirements is a prerequisite for adopting an integrated and improved network logic that helps reduce the Journey Gap. Improving the experience of using public transport beyond just basic service requirements is necessary to achieve advanced modal share targets once quick wins for reducing the Journey Gap are exhausted.

5.1.3. Recognize, Accept and License Paratransit

Paratransit reduces the Journey Gap, across the geographical boundaries and the economic spectrum. It should be considered as a solution where possible, and integrated in planning. To shift the modal share inside NDCs, an amelioration of the dominant paratransit services is critical. Barring some historical examples in what are now cities such as Hong Kong[17], most cities with more limited budgets have not managed to comprehensively replace paratransit services. Thus, a stronger strategy is to explore ways to reform paratransit. Paratransit operators can either be encouraged to join a new formal system but their operation and regulation are left open and their future role undefined or unrecognized and they continue to operate under poor regulation and do not integrate with new formal systems or they can be upgraded and better integrated into mass transit (Schalekamp and Klopp, 2018). Overall, *Regulating paratransit is a prerequisite for adopting a hierarchical improved network logic and integrated multi-modal public transport (to reduce the Journey Gap, and improving the public transport experience).*

To improve local intra-NDCs paratransit services, taking El–Sheikh Zayed as an example, the first step would be to bring the operators into a system regulated by local government, followed by registering drivers and providing permits. Inspired by the example of Dakar, El-Sheikh Zayed City should first issue permits which establish the route as the unit of regulation (as opposed to traditional models of the bus or the operator licensing). Operators would still have complete commercial responsibility, and be subject to basic requirements in relation to issues such as vehicle safety, standards, environmental control, and stopping.

Furthermore, a selection of new peak-only, high-quality private rapid paratransit services (Buseet, SWVL) have eschewed established hubs fully and operate on their own self-determined routes, catering to a more upmarket clientele. Unlike paratransit services, they tend to operate only a limited number of trips a day, and thus cannot be considered proper public transport. Still, they further prove that paratransit-like services remain competitive and hence desirable in certain scenarios; and are inevitable in maximizing accessibility. **They should be recognized, accepted and licensed by PTAs**. Upgraded paratransit services must also carry the majority of

17 Hong Kong managed to replace their paratransit services, which dominated service provision in the 1970's, and invested heavily in a highly sophisticated integrated multi-modal system with a tap card and real time information systems. Dubai formalized their informal taxi services in a 20-year process starting in the 1990s.

public transport users and will remain part of tomorrow's public transport systems.

5.2. Shifting Travel Between NDCs and Inner-City Cairo Through Public Transit

Improving regional service provision of transit travelling between NDCs, and inner-city Cairo can reduce the identified journey time gap and ameliorate the public transport experience service. It acts as a catalyst for (a) moving people away from private cars and towards transit, and (b) enhancing the accessibility of NDC residents, thereby contributing to population relocation and NDC development towards functioning communities.

5.2.1. Planning and Management of Land Use and Mobility

Urban sprawl ***increases the Journey Gap*** *since it increases the areas served exclusively by car. It needs to be controlled and discouraged, and NDCs designed to be more compact.* At the metropolitan scale, GCTRA should take an active role in working with stakeholders to minimize the need for individual motorized travel through adequate land use. Some urban forms lend themselves to shorter-distance travel than others, and GCTRA can play an active role in identifying the best urban forms and working with NUCA to steer urban development. For example, recent expansions of the urban area such as the reclassification of the 'Green Revolution'[18] land within El-Sheikh Zayed City from agricultural to urban are worrying from a transportation as well as a food security and overall environmental perspective. Sprawl obviously increases distances covered and vehicle miles travelled (VMT). Compared with compact cities, sprawling suburbs have been linked with a decrease in transit use, an increase in traffic fatalities (Ewing et al, 2003), and an increased risk of diabetes and cardiovascular disease due to a less active lifestyle (Stevenson et al, 2016). Mixed-use dense city areas often reduce need to travel, encourage active travel and produce a significantly higher demand for public transit trips compared with sprawling areas, enabling transit to function and exist.

18 Green revolution refers to the introduction of High Yielding Variety (HYV) of seeds and increased use of fertilizers and irrigation methods.

5.2.2. Express, Rapid or Local? Adopt Hierarchical Network Logic for Urban Transport Planning

Adopting a network logic based on best sustainable transit planning principles such as EASI would systematically reduce the Journey Gap across all districts of the metropolitan area, and all journeys. PTAs should work to align long-range express inter-city services and mass transit backbone service with short-range local intra-city services into an optimized network based on high quality service network logic. For example, currently, there are two major and separate transport hubs within El-Sheikh Zayed City: a paratransit hub at Hyper One, and a formal hub located in District 16. As these services continue to evolve in an organic manner based on point-to-point travel, they form an incoherent and inefficient network. With the aid of GCTRA, the El-Sheikh Zayed City Authority can transform the current transit network into an optimized one based on service network logic. It should ensure complementarity between long-range express inter-city services and short-range local intra-city services.

5.2.3. Managing Public Space, Roads and Parking

Zoning, street redesign, limiting and pricing parking can be leveraged to make cars less attractive and ***reduce the Journey Gap*** *as well as* **transform the experience of the walking and cycling environment.** Improved design and layout of street space (sidewalk widths, public lighting, trees, continuity and accessibility) and transport facilities with well-designed gateways and routes to and from public transport are key tools in this effort. Keeping public spaces clean, safe, free from degradation, and clear of obstacles, such as parked cars over is critical and an employment generator. These efforts inevitably benefit public transport use, as any public transport trip begins and ends with an active trip to a stop.

Street and parking management are particularly important. Parking rules and spaces should be delineated and enforced, and preferably priced. Due to their vast open spaces, NDCs, in particular, are prone to uncontrolled and unsafe parking practices. These should be discouraged and expectations should be defined and set clearly.

6. Conclusion

Current urban mobility practices in Egypt do not appear to address the fundamental issues facing accessibility and mobility in New Desert Communities. Multiple concerns emerge in relation to the ability of organically grown paratransit networks and their myriad of point-to-point services to provide a consistent, high-quality service throughout NDCs, which, in turn, would increase their attractiveness and value. As this analysis shows, paratransit's best performance relative to private cars happens on long-range point-to-point routes connecting NDCs with downtown Cairo. However, even then, trips averaging 1.5 h in a single direction require extensive walking or private last-mile services, and a considerable time premium compared to private cars. Computing the Journey Gap reveals that paratransit systematically fares worse in connecting NDCs with each other and in ensuring urban mobility within them, often taking up to two or three times as much time as private cars.

Consequently, without significant restructuring of the internal NDC networks, concentrating investments in one corridor connecting NDCs with each other and with inner-city Cairo is likely to culminate in failure. The series of recommendations we propose are tailored towards avoiding this scenario by improving Journey Gaps. This is in line with the EASI-framework which clearly shows the importance of enabling target-oriented governance of urban mobility. Overall, carefully thought out enabling policies such as those we propose including building and sustaining organizational and technical capacity, and engaging with existing stakeholders are international best-practices, and a pre-requisite for the success of any infrastructure capital investment.

It is important to note that these recommendations are not based on current ridership numbers, which are below potential due to the inherent weakness of the system, but on the potential of unlocking massive unmet demand not just for transport but for housing that is located with high accessibility. Increasing accessibility would thus increase the value of these homes and local productivity and livability. More systematically measuring and strategically tackling accessibility must become a main policy goal, and doing so with the understanding of the importance of controlling modal share is the key to achieving sustainable development and meeting the SDGs. Computing the Journey Gap, and assessing recommendations based on its effect on the Journey Gap, is an easy way for getting transit planning on the right path.

Planning for sustainable urban mobility and access provides a real opportunity for creating even more employment, including in the paratransit sector, while slowly formalizing it in steps and improving sector conditions. The key is also transforming the experience of walking and cycling through more cutting edge design of street space. Part of sustainable urban mobility planning must also involve locating public transit intermodal stations strategically within the pedestrian and cycle-friendly network of side roads and main roads, and minimizing walking distance and time to access the transit network, while surgically removing network inefficiencies. Overall, in line with global trends, a more citizen-centric approach to urban mobility planning could affect not just how millions of Egyptians commute to work every day, but also their choices of where and how to live and as a consequence, revitalize the nation's biggest investment: New Desert Communities, while at the same time addressing national commitments to address climate change and the SDGs

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Appendices

Appendix A: Limitations of the Methodology and Data

The methodology used here falls short in three issues: (1) Our limited operationalization of accessibility, (2) the lack of high quality data, and (3) the insufficient attention given to the affordability of trip choices. Each limitation is explained in more detail, and if possible, pathways for future research or methodological improvement are laid out.

0.1. Limited Operationalization of accessibility

In our operationalization of accessibility, we focus mainly on the transportation component, while suspending the land use, temporal and individual components. Although this somewhat reduces the analysis to examining and comparing *mobility* across different modes, *mobility and accessibility* are intricately linked. This study computes "nominal access", or the potential for physical access across neighborhoods. The link between "nominal access" and "effective access," actual travel behavior and transport demand, is a logical next step to improve the validity of the results.

0.2. Lack of High-quality Data

The use of the GTFS data created by *Transport for Cairo (TfC)* as part of the Digital Cairo project enabled this hitherto not possible form of analysis in Cairo. Still, a number of limitations and potential for future improvement of the data need to be mentioned:

- The geographic scope of the data is the GCR, focusing on NDCs. We collected all intra-city services originating and ending within six NDCs: El-Sheikh Zayed City, Sixth of October City, New Cairo, El-Obour City, El-Shorouk City and

Badr City. These services include routes within NDCs, connecting NDCs with each other and connecting NDCs with inner-city Cairo. The data does not include services originating and ending within inner-city Cairo. At present, this limitation does not affect the accessibility metrics, as the studied itineraries always include a comprehensive set of available services and service combinations.

- To compute travel time, we relied on weekday morning rush hour as the basis of our model. While the temporal data accounts for traffic, it does so based on data estimated for an out-of-school period. The variability of traffic congestion, and thus reliability of the utilized estimates for travel time should be included in future analysis. This will become possible as more data is collected over a long period of time, a process that is ongoing. At present, however, neither limitation would change mean performance of modes, all of which compete for limited road space. However, anomalies might exist in the extreme cases (e.g. high/low levels of congestion)
- Several simplifications were taken with regard to public transit travel time estimates. Frequency is estimated at 5-minute headways, regardless of mode or time of day; due to insufficient ground data. Operating time for services are assumed as constant and unchanging throughout the day. Operating speeds are computed based on travel time for private cars, and a public transport penalty: while both public transit and private cars suffer from the same congestion, public transit needs to account for stop dwell times, and acceleration and deceleration between stops. In the future, on-field data collection could allow frequency and operating time estimations by mode or route; while improvements to the travel time computation model could distinguish between different modes, and for instance, more accurately reflect the speed benefit of paratransit over formal modes of transport. At present, these limitations show public transit more favorably than is probable in reality.
- While the trip anatomy comprehensively covers all steps of a trip using public transit, it falls short regarding private cars by not accounting for (a) time spent looking for parking when driving private cars, or (b) time spent waiting for ride-hail vehicles. No standardized data collection methodology exists for (a), while (b) could in the future be computed using publicly available API's of existing ride-hailing companies. At present, these limitations show private cares more favorably than is probable in reality.
- The quality of the walking infrastructure is unaccounted for; street characteristics such as pavement, shading and pedestrian crossings have a huge impact on access that we do not capture. At present, this limitation does not affect the computations, but rather limits the interpretability of results. While times computed for walking/public transit will stay the same; quality of walking infrastructure can serve as a powerful deterrent for use of both, despite a potentially computed preference.

Finally, there is a lack of publicly available data on demographics and counts of residents of NDCs, making the operationalization of the individual component of accessibility impossible.

0.3. Affordability of different trip choices

a powerful limitation as not all residents of NDCs can afford all options, and in particular cases, might choose suboptimal public transit itineraries, as they are cheaper. The analysis always shows the *fastest* itinerary, irrespective of cost. A more widely accepted form of analysis combines between travel time and cost to compute the **generalized travel cost**, which adds the time value of travel time to actual travel cost.

Appendix B: Transit Fare Structure within the GCR

Mode of Transport	Operator	Average Fare EGP/km	Average Fare US cent/km	Public Bus = 100	Average Route Length in km
Commuter Rail	NRA	*NA*	*NA*	*NA*	*NA*
Metro	ECMMO	*0.03 EGP/km*	*0.2 ¢/km*	*167*	*25.9km*
Public Bus	CTA	*0.05 EGP/km*	*0.2 ¢/km*	*100*	*40.5km*
	CTA Minibus	*0.09 EGP/km*	*0.5 ¢/km*	*180*	*34.7km*
Paratransit	Co-op	*NA*	*NA*	*NA*	*NA*
	Microbus	*0.21 EGP/km*	*1 ¢/km*	*420*	*25.7km*
	Suzuki	*0.43 EGP/km*	*2.5 ¢/km*	*860*	*9.1km*
	Box	*0.3 EGP/km*	*1.7 ¢/km*	*600*	*7.1km*
	Tok-Tok	*NA*	*NA*	*NA*	*NA*

*Fares calculated in EGP per km travelling the entire route across the network.
**Computations by author, based on data collected through the Digital Cairo project.
NOTE: This data reflects pricing during the Oct 2017-March 2018 period; i.e., before the fuel price adjustments of July 2018, as fares have since risen.

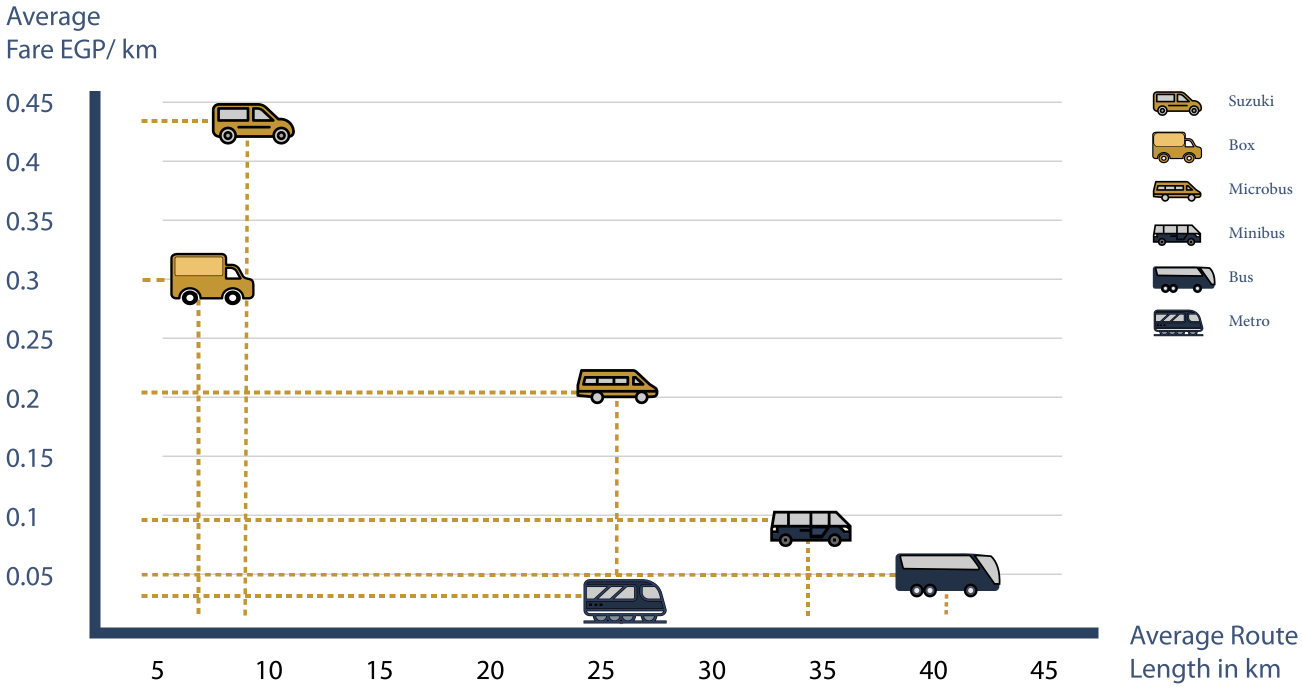
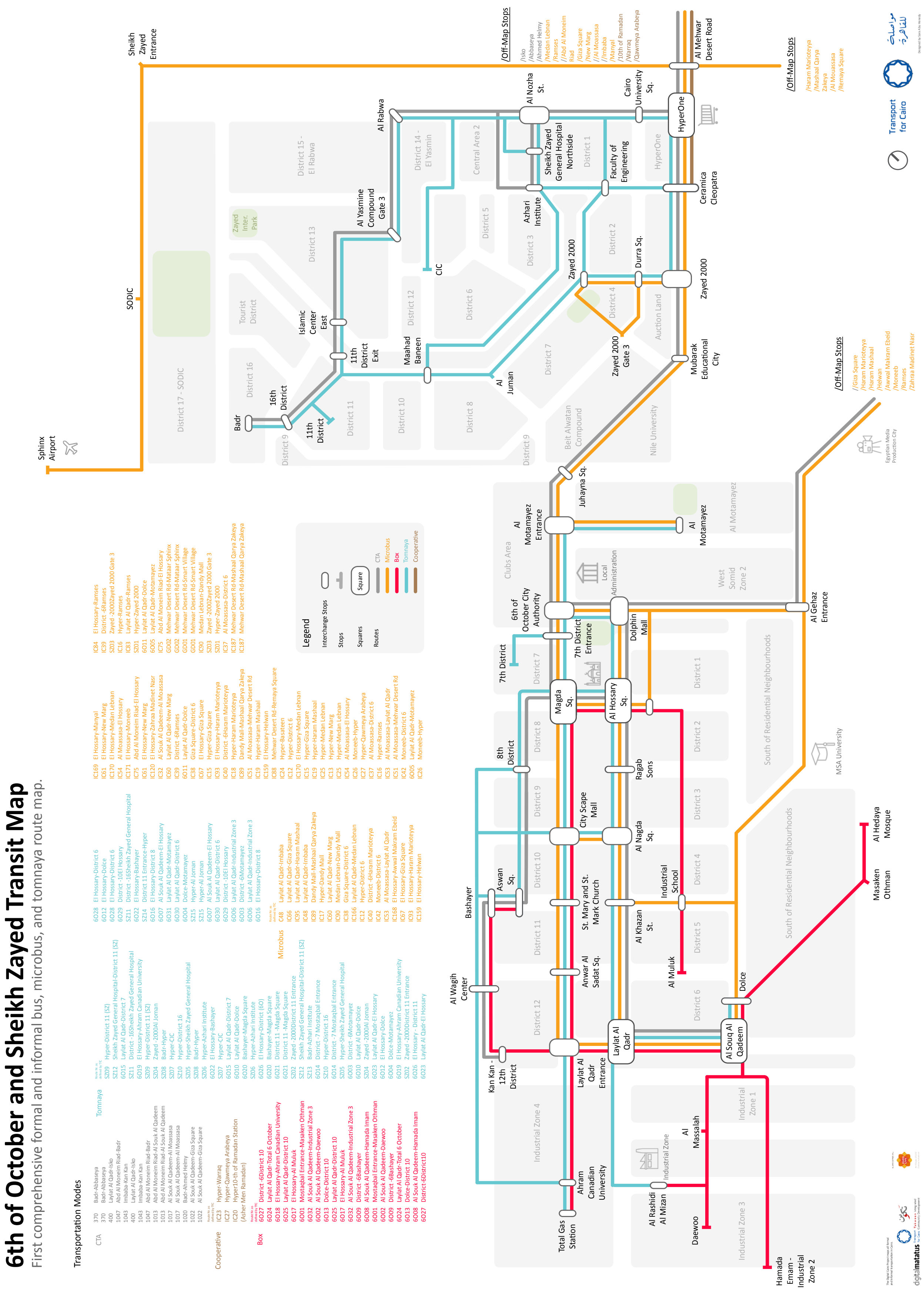


FIGURE 10 Transit Fare Structure within the GCR

Appendix C: Schematic Representation of the Full Public Transit NetWork of Western NDCs



(Designed by Sara Abu Henedy, TfC, 2018)

Appendix D: Potential Mobility Index

Potential Mobility Index (PMI) is defined as the quotient of the aerial or Euclidean distance and the travel time on the transport network between origin and destination. Thus, a PMI score is calculated using:

$$PMI(i) = \frac{1}{n}\sum_{i=1}^{n} \frac{d(i \ldots j \ldots n)}{T(i \,..\, j \ldots n)}$$

where

PMI(i) is average aerial speed for zone *i*,

d is distance between *i* and *j*

T is the travel time on the network between *i* and *j*

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