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Research Study on Urban Mobility in Greater Cairo; Trends and Prospects

Final Report

DRTPC Study Experts



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Research Study on Urban Mobility in Greater Cairo; Trends and Prospects

1. Introduction

Based on the methodology, outlined in the Inception Report (1) and the Interim Report (2), the current report gives the findings of this research study. We start by reiterating the study objectives and scope.

Main objectives:

- To improve knowledge about mobility and transport evolution trends and impacts in Greater Cairo (GC) in connection with urban expansion and energy/environment, so as to call attention of decision-makers and other stakeholders to the related effects on sustainable development and sustainable transport.
- To favour an integrated research approach on urban mobility, Transport Engineering and Planning, Urban Planning and Energy/Environment Engineering fields.

Scope of work:

The scope of the research covers evolution trends of urban development, transport and energy/environment in the GC area encircled by the Ring Road including the Pyramids Plateau in the South West and the International Airport in the North East as shown in Figure 1. The years for which the trends are analysed, namely the governing years, are those in which transport supply/demand data are available from past transport studies (1971, 1978, 1987, 1998, and 2001), as explained in Sections 2 and 5.

Structure of the Report:

The adopted methodology is described in Section 2 and we give in Section 3 a brief on Cairo early beginnings. Section 4 addresses the evolution of urbanization in GC in the governing years and describes current urban structure. Being a pioneer experience of Egypt, the New Cities around GC are also touched upon. Section 5 is devoted to analysis of the evolution of GC transport demand and supply in the governing years. It, therefore, summarises the past transport studies and surveys based on which the governing years are identified. The current situation of GC transport demand and supply is given with brief on institutional and financing issues. Section 6 analyses the evolution of the impact of transport on energy consumption, greenhouse gas and pollution emissions in the governing years, including analysis of the GC road-based transport fleet. The section starts, however, with highlights on Egypt energy sector and greenhouse gases. Section 7, analyses the evolution and current impact of the Metro on saving fuel consumption, and fuel cost and greenhouse emissions; a topic that is vitally important in a grand metropolis like GC. Links between land use, transport and energy/environment are explained in Section 8; focusing on transferable lessons on elements of land use and transport that cause energy/environment impacts and the applied mitigation policies/projects. Section 9, gives a closing note and suggestions on needed actions to improve urban quality, transport and energy/environment; based on findings of the study and GC experience in applying mitigation policies/projects; focusing only on doing what works!

2. General Methodology

The general methodology is based on two lines of thought. First, to know the trends of evolution over the past four decades of transport supply, demand and mobility, as related to those of land use and urban development; and the evolution of energy consumption and air quality trends as they relate to those of transport expansion. This leads to extracting lessons and conclusions supportive of sustainable transport and sustainable development. Second, throughout the research, the experts emphasise the other objective of the study calling for integrated research approach between the experts of the three interacting fields of "Transport Engineering and Planning" and "Energy/Environment Engineering" from one side, and "Urban Land Use Planning" from the other. Besides, for the "energy and environment" as related to "transport", the methodology sheds light on issues of local and global ecological and economic sustainability, with respect to saving non-renewable energies, improving local air quality and reducing greenhouse gas emissions related to global environmental effects. Focus is further placed on the effects of GC metro, the first in Africa and the Middle East, opened in 1987, on those respects. This is a third, but not less important, aim that is though not stated in the TOR, yet the research team hopes to be able to address whenever possible.

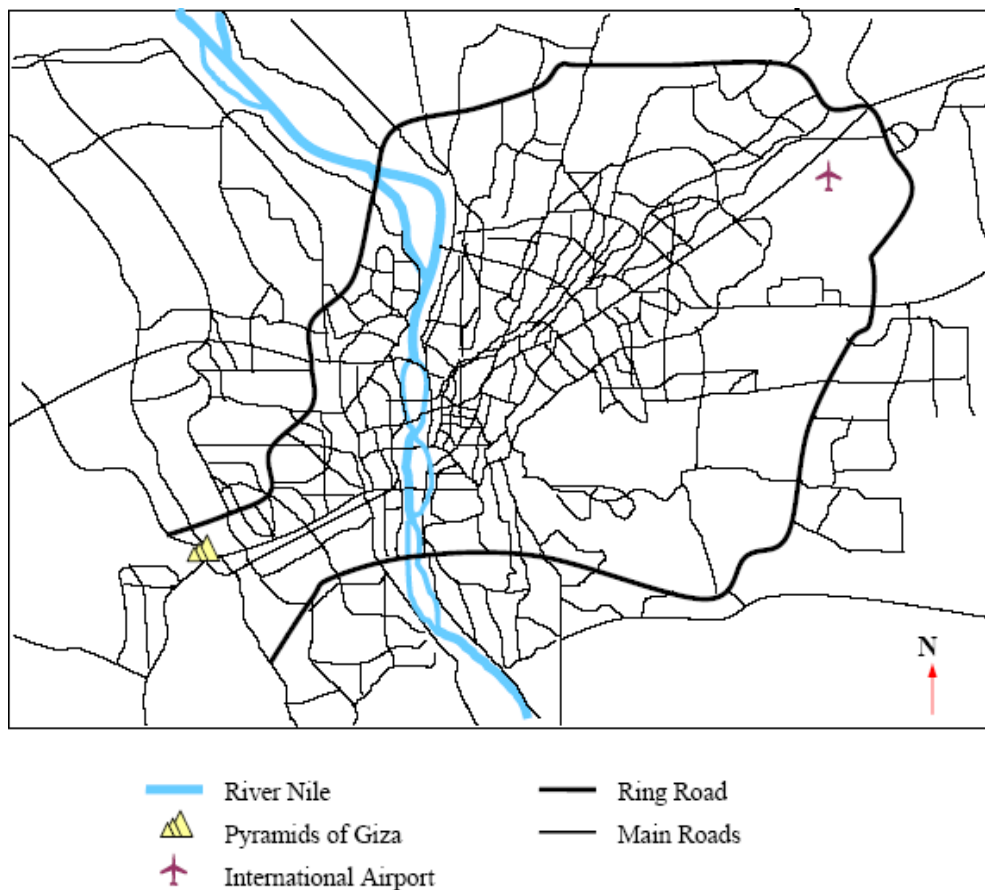


Figure 1: Greater Cairo area considered in the current research study

Figure 2 shows a self explanatory outline flow chart of the general methodology adopted by the study experts. It links the development and expansion trends of the above mentioned three interrelated areas that are dealt with. The considered years for shading light on urban expansion of "Cairo" goes back to the establishment of the capital in 640 and to the later slight shift of location in 969, till the 1960s of the 20th century; the objective is to record some interesting historic features of this very old city in an informative, but not analytical, manner. However, the analytic considerations of urban expansion, population growth and land use development relates to the evolution between the 1970s and the 2000s in general terms and relates, in particular, to the "governing years" for which transport trends are analysed as explained below.

The "governing years": for transport evolution, expansion trends of supply and demand are tied to the years when the travel demand surveys of GC Transport Studies were conducted in 1971, 1978, 1987, 1998 and 2001. Those are the five "governing years" which are explained more in Section 5 and that are the basic years for matching urban development and energy/environment trends with those of transport.

Quantifying energy consumption and exhaust emissions resulting from the use of transport modes needs to be estimated based on mathematical calculations in absence of real world data. Hence, assumptions and adjustments are used as mentioned below and explained more in Section 6.

At the geographical/jurisdictional level, it should be noted that GC had included since the beginning of its regulative declaration in the late 1960s, an area that belonged to three governorates; Cairo Governorate, a totally urban governorate, the northern urban part of Giza Governorate and the southern urban part of Qalubia Governorate. This has important bearing on the methodology. While we address the mega metropolis, GC, statistics such as population census and car registration, for example, are published at the governorates level. Accordingly, all previous transport and other studies and reports that addressed GC, had to resolve to assumptions to correct for this. Furthermore, one of the previous major Transport Studies considered an enlarged area covering the region outside and surrounding GC including semi rural and rural fringe areas and new cities in the north, north east and west of the agglomeration. Moreover, very recently in early 2008, two new governorates were established; "Helwan Governorate" to include some parts of southern Cairo and its north east new urban development cities, and "6 October Governorate" to include some parts of southern urban Giza and the new urban development cities in the west external to the Ring Road. This means that currently Giza Governorate includes urban Giza only, and Cairo Governorate has been also reduced losing some districts to Helwan Governorate.

As a consequence, now GC shall be shared by five, instead of three, governorates and its area will be larger than the current area extending out of the Ring Road in some parts. Because the details and the new regulative policies of the new arrangements for GC were still in progress during undertaking the present study, it was impossible to adopt the methodology and to adjust the statistics and information to take these changes into account, except only as a very general background. Accordingly as mentioned in Section 1, the considered area of GC is that encircled by the Ring Road as presented in Figure 1.

To achieve the objective calling for comparisons of the evolution and establishing the trends of urban expansion and transport supply and demand as well as the related energy/environment elements, the need for applying adjustments and assumptions on many data items is absolutely necessary. Obviously, for meaningful comparative analysis, the compared elements must be estimated on the same grounds. This means that values of the items that shall be compared over the years for each of the previously mentioned three areas of the research, for instance, must;

- have the same definition,
- be quantified with the same units of measurement,
- be also quantified at the same geographical unit (e.g., jurisdiction zone),
- be presented at the same level of aggregation (e.g., GC boundaries),
- be measured using the same method and with the same level of detail and accuracy,
- etc.

Therefore, considerable effort is made by the Study Experts in order to arrive at reasonable assumptions and adjustment factors of many data items.

Finally, it should be noted that throughout this work the research team uses only published and accessible reports as stressed clearly in the TOR and the Study Agreement and as explained in the previous reports (1 & 2). Accordingly, main available and published accessible reports under the three areas of study, "Land Use and Urban Development", "Transport" and "Energy/Environment" are searched and listed in the previous reports (1 & 2). Some of the reports include parts on these three areas of the study, while others only focus on one of the three. In addition, some of the reports which though may not be directly addressing those three areas of interest are referred to; because they serve as useful background or used for setting out assumptions and/or are anticipated to serve the conclusions in the end of the work. Furthermore, reference is made, whenever the need arises during the course of the work, to research papers and/or thesis as well as reports that are not listed in the previous reports (1 & 2); and thence are mentioned in the current report.

3. Cairo; the Distant Beginnings

As mentioned in (3), the very early capital of Egypt was Thebes near Luxor, Upper Egypt. Later and for five millenniums the capital had been Memphis on the Giza Plateau some 15 km to the south west of the present location of Cairo. In modern history the capital was called Al Fustat, established 640 around the ruins of an old Byzantine castle, Babylon Castle, located on highlands overlooking the River Nile.

This took place at the start of Islamic Egypt under Amr Ibn El Aass coming from Arabia in 640 (4) to the welcome and cooperation of the Copts of Egypt who were relieved by his presence as he was determined to salvage them from the torture of the Eastern Roman Empire invaders and secured from the first day, peace, equity, justice and freedom of choice and practice of religion. The Mosque of Amr Ibn El Aass still exists in Al Fustat District of present day Cairo and is one of the shrines for the visitors of the capital.

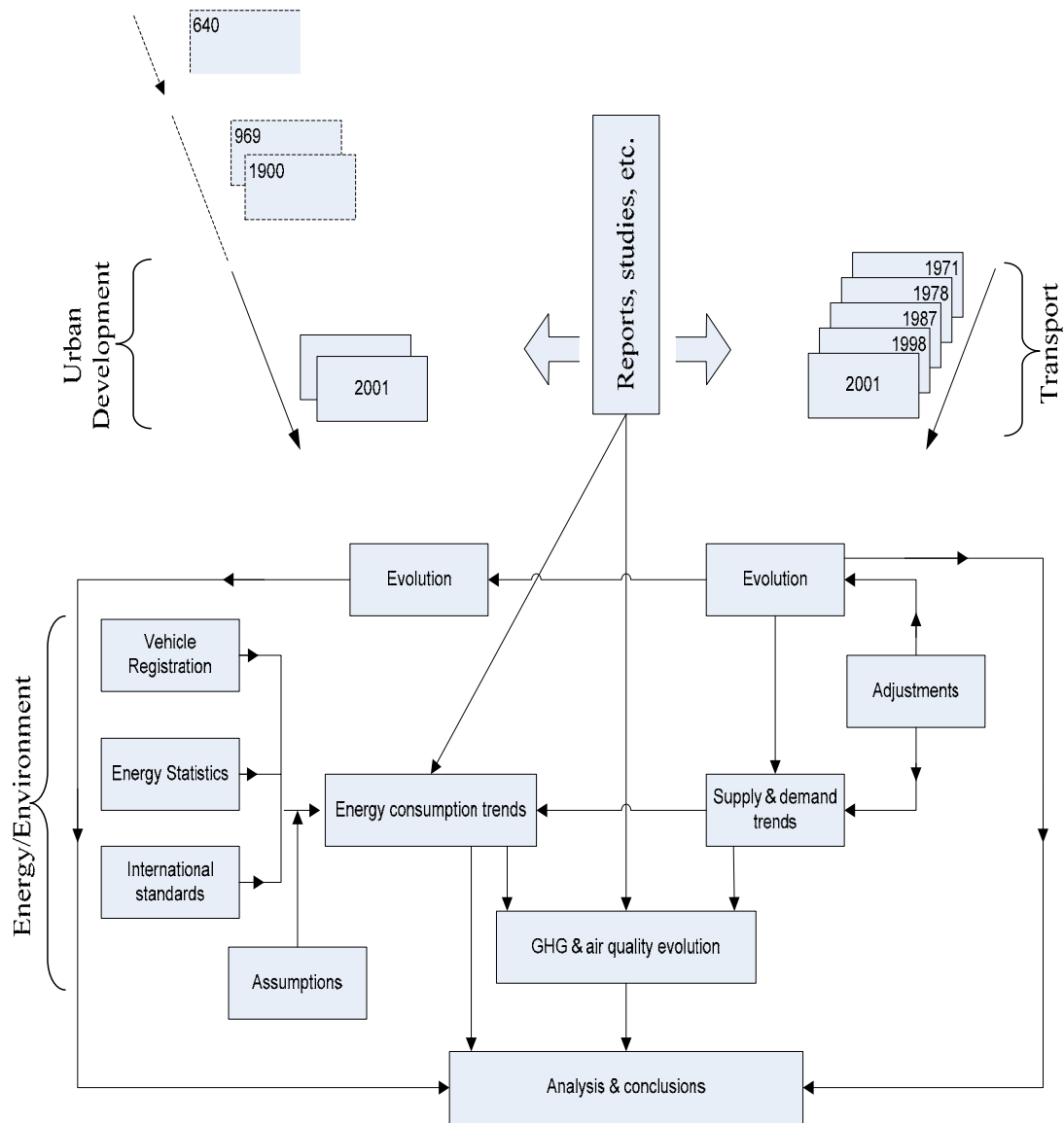


Figure 2: Outline flow chart of the general methodology.

Later, two successive very adjacent sites housed the capital, namely Al Askar founded by the Umayyads in 750 and El Qatai founded by Ahmed Ibn Tulun in 868, (5), where a famous Mosque under his name still exists. In 969 Gohar El Sakally, the Army Commander under El Moezz LeDin Allah Al Fatamy, the Fatymmiate ruler coming from north Africa, moved the capital to another location very few kilometers to the north east of Al Fustat, naming it Al Qahirah (Cairo). They built Al Azhar Mosque in the same year, 969, which also houses Al Azhar University; the oldest University in the world starting as an Islamic Studies University and in 1961, only 8 years before the calibration of its 1000 years anniversary, the University introduced modern Faculties of Medicine, Engineering, Science, Commerce, etc., and a number of religion and science research centers and institutions as well. The city was encircled by a wall with different Gates, the most important of which are Bab Al Fateh, Bab Al Nasr and Bab Zoowialla are still existing and attracting the visitors of Old Cairo.

In 1171 Saladin ended the rule of the Fatymmiates, extended the wall of Cairo and constructed Saladin Citadel on the Moquattam Hills Spur (4) that houses the Mosque of Mohamed Ali, the Military Museum and other tourist attractions that are intensively visited to date. It is reported (6) that some 20000 flats and similar number of shops existed in Cairo at the time when Cairo was first established in 969 and that by 1340 the population reached 500000 inhabitants five times more than the population of Fatymmiate Cairo (7). The city expanded further and further since those early years of its very beginning as presented in Section 4.

4. Land Use and Urban Development

4.1 Urbanization in Egypt; General Overview

World urban population has been increasing over the last 50 years. In the period 1950 to 2008, global urban population increased more than four times, jumping from about 800 million to about 3200 million and is projected to increase to 5000 million in 2030 (8). Furthermore, over the period 1975 to 2000, world urban growth rate reached 2.68 compared to a global population growth rate of 1.75. Egypt witnessed a similar trend of urban population increase. Between 1950 and 2000 urban population jumped also four folds from 6.9 millions to 28.4 millions; with average growth rate of 2.8, which is very close to the global average nearly during the same period. This rate decreased to 1.82 in the following five years between 2000 and 2005, (9).

4.2 Evolution and Expansion of Urbanization in Greater Cairo

4.2.1 General evolution

GC is the largest urban area in Egypt, Africa and the Middle East and one of the most populous metropolises of the world. Cairo occupies the 10th rank within mega cities across the world in the period between 2000 and 2015 after it was the 12th in the period 1975 to 2000 and the 13th from 1950 to 1975, (8). Over the 20th century the population increased from 0.6 million in 1900 to more than 10.5 millions in 2000 (10). Figure 3 shows the evolution of GC population versus Egypt population and the percentage of GC population to that of Egypt. On average GC population is about 15% of the population of Egypt and this is projected to continue for the coming 15 years.

The second largest urban agglomeration in the country, Alexandria, did not exceed half the above percentage as in 2000 its population reached just around 5.4% of the total population of Egypt (9).

The growth rate of GC population decreased steadily after the 1970s due to government policies; allocation of more funding to develop the capitals of the 28 governorates and other major cities, and the start of the pioneer policy of new cities. Contrary, between 1950 and 1970 all development projects were focused mainly in Cairo and Alexandria, neglecting the other cities. As seen for Figure 4, compared to other mega cities, in the period 1975 to 2000 annual population growth rate of Cairo was 1.8; the highest rate was 7 in Dhaka and the lowest was 0.2 in New York. Furthermore, it is projected that Cairo growth rate will decrease further to 1.3 in the period 2000 to 2015 compared to the projected highest rate of 4.1 in Lagos and smallest rate of zero in Osaka, (9).

The rate of natural population growth in Egypt in 1966 was 26% and became 30.4% in 1985, and started to decrease continuously until it reached 21.8% in 1996 and 19.5% in 2006. Reasons include the increased economic pressures on many of the families and the eventual diversion from an agricultural society, believing in the importance of the family to have many children, to a new era of industrial, development, information technology, commerce, business and the culture of the 21st century. In addition, the successes of birth control and family planning programmes have contributed much. International recognition came in 1994 when President Mubarak received the UN Population Council Award for that achievement of Egypt.

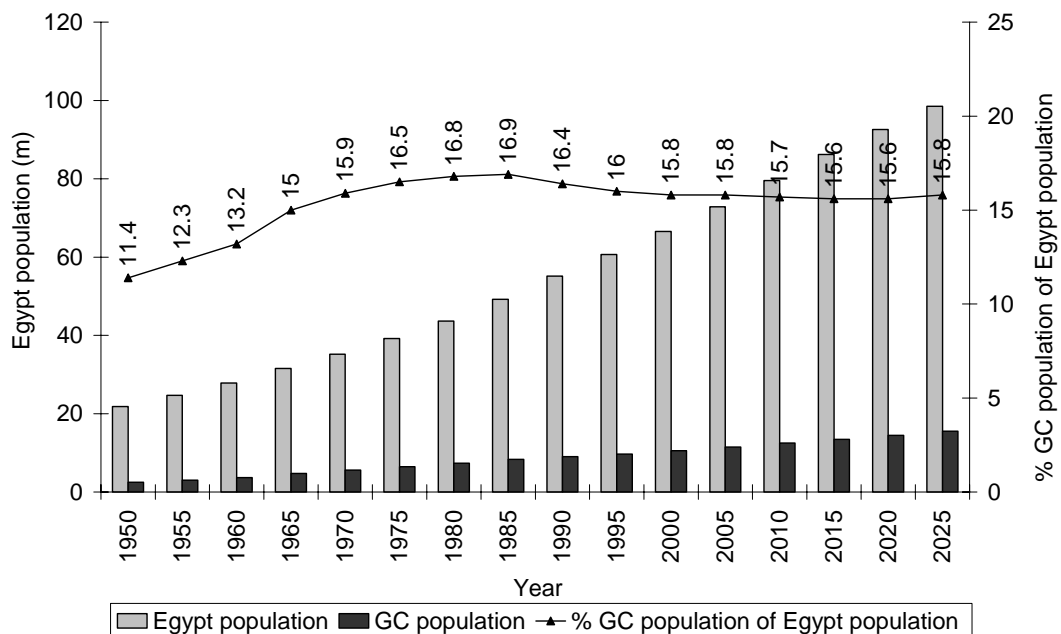


Figure 3: The evolution of Greater Cairo population versus Egypt population, (based on reference 9).

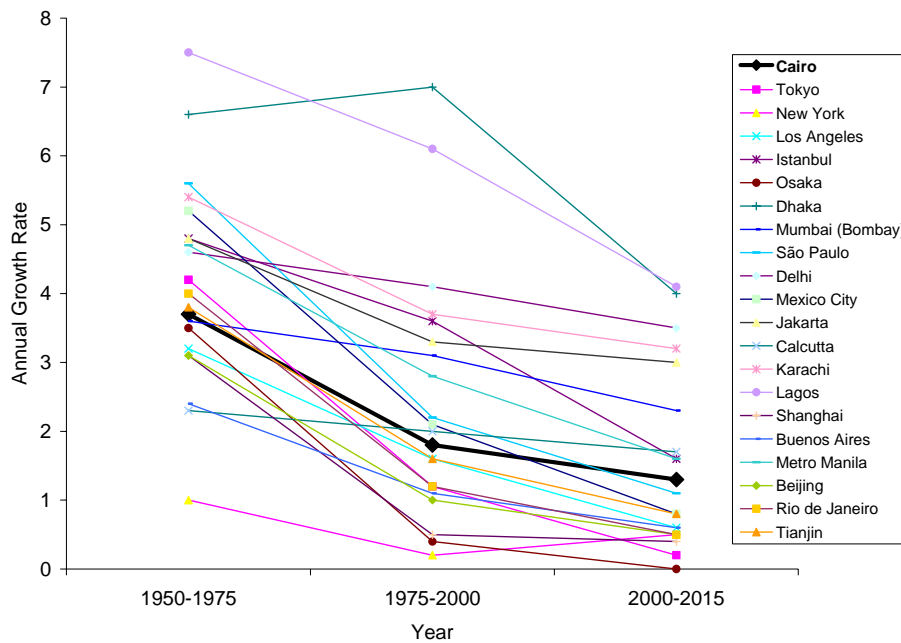


Figure 4: The evolution of annual growth rates of population in mega cities by 2015, (based on reference 9).

Figure 5 shows sketches (not to scale) of the expansion of Cairo since its early beginnings in 980, just 11 years after its relocation to the new site in 969 (see Section 3) till recent times in 2000 passing by the 1960s when the "GC" terminology started to be used. It is seen that the city was established under the spur of Al Moquattem Hills (150 m above Sea level) side and extending towards the River Nile shore banks in the west. Later in the 1960s and 1970s expansion started to climb over the hills and to cross the River creeping to Giza where the Pyramids Plateau exits, and also to the south to the, then, newly established industrial estate Helwan in the east of the River, and to the other industrial estate in the north "Shoubra Al Khima". In the 1980s and 1990s the expansion covered wider areas in the north east, the west and the south as seen from Figure 5. So, the establishment of new districts took place successively in the last 150 years, as Shoubra in the early and mid 1880s, the CBD in the late 1880s, Heliopolis and Al Manial in the early 1900s, Al Dokki in the 1950s, Al Maadi and Helwan in the 1940s and 1950s and Madinat Nasr and Al Mohandesseen in the 1960s, Faisal and Al Moquattam in the early 1980s, etc. In addition some sites housed random expansion over some of the surrounding agriculture lands in the west, the east, the north and south peripheries as discussed in Section 4.3. The above dates are approximated as it is out of the scope of the current research work to go deeply into this historic development subject of Cairo. The urbanized area, therefore, also increased over the years. The recorded area in 1968 was 160 km sq and reached 290 km sq in 2000.

The gross density of GC also increased over the years as it was 29000 persons/km² in 1945, increased to 32000 persons/km² in 1982 and to 39000 persons/km² in 2001.

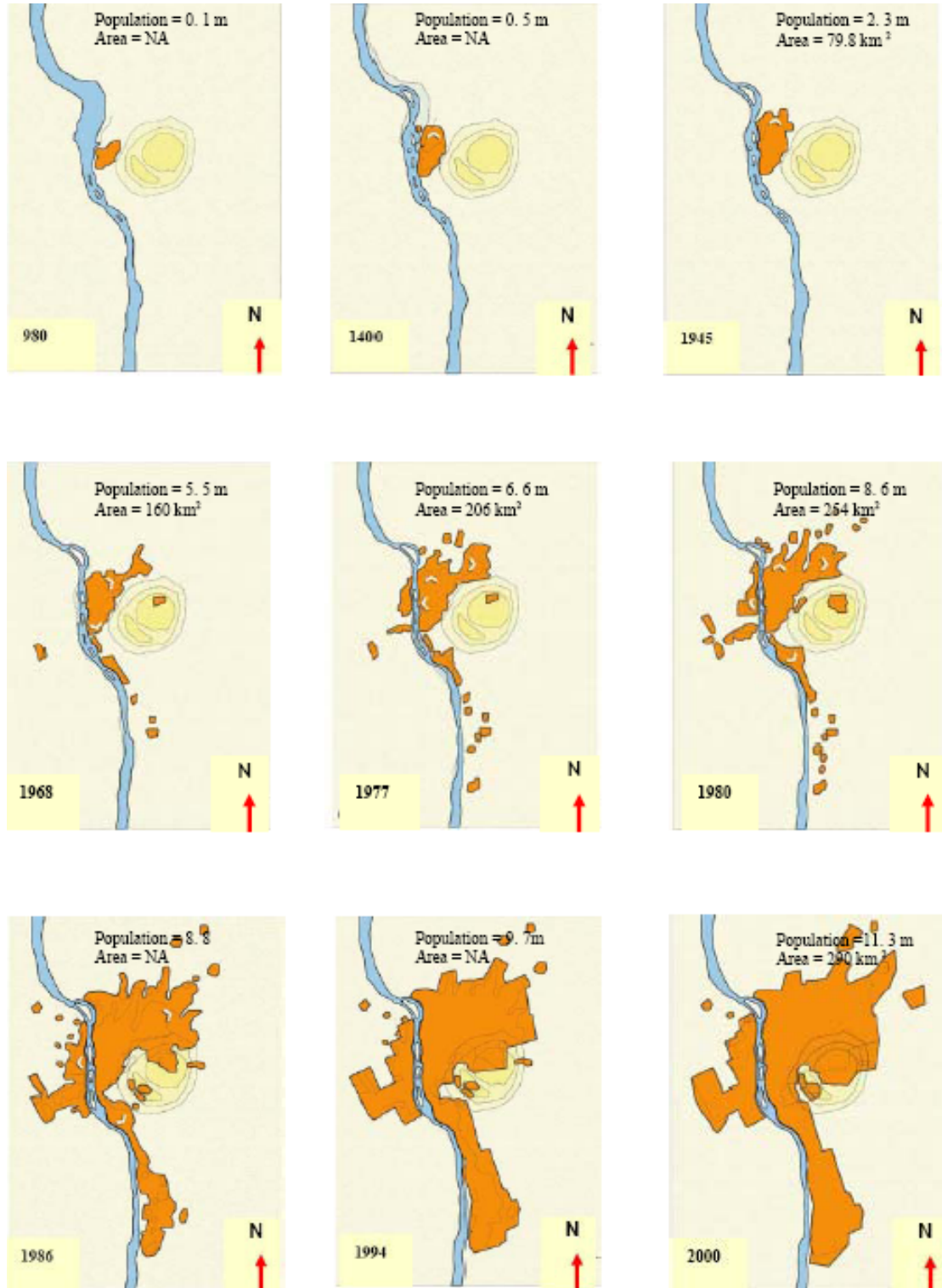


Figure 5: Evolution of Greater Cairo urbanized area and population in selected years from 980 to 2000, (areas and population values are worked out based on selected references including: 6, 10, 11, 12 & 13).

GC comes in the fourth rank of the highest densities across mega cities in the developing countries. The first three are Mumbai, Dhaka and Manila, respectively, (12). Reasons of the continuous increase in population, urbanized area and population density of GC are not different from those practiced in other major metropolitan areas in the developing countries. These mainly include increased migration from rural areas, which played a very important role in the growth of urban population in Egypt in general and in GC in particular. However, this started to decrease after the late 1970s due to the policies mentioned earlier in this section. Statistics of 1976 show that the number of internal migrants to GC reached around 1.1 million and those of the 1987 indicate they decreased to 0.9 million. GC employment doubled over the last 30 years. In 1981 it was 1.6 million and reached 4 million in 2001 (10). The accumulation of investments and the increased economic activities resulted in increasing the number of job opportunities in GC in 2001 compared to 1981.

As for the number of students in GC, the second half of the 20th century witnessed high growth rates. The total number of students in 1998 reached approximately 3.4 million, including students enrolled in all education levels from primary school to University, whereas in 1987 this number was only 1.7 million students. This increase is reasonable as the population was increasing in the same period and the increased awareness of the importance of education was also increasing among all groups of the population.

4.2.2 Evolution of Greater Cairo urbanization in the governing years

As mentioned in Section 2 and later in Section 5, GC evolution analyses is based on five governing years tied with the dates of the transport surveys carried out in 1971, 1978, 1987, 1998 and 2001. The current section, therefore, serves as a background for the analysis of the evolution of transport and energy/environment given in Sections 5 and 6, respectively. Bearing in mind the analyses given in Section 4.2.1, a brief on the evolution of urbanization of GC in the governing years is given below.

It is clear from Table 1 and Figure 6 that the growth rate of GC population remained consistent from 1971 to 2001 at the value of 1.16. Urbanized area of GC during the period 1971 to 1987 increased by 160% and during the period 1987 to 2001 by 115%, as many informal expansions took place before 1987 in addition to some planned expansions on the periphery of the existing urban area. Examples of these informal expansions are mentioned in Section 4.3 (e.g., Bulak El Dakroul) and examples of planned expansion are mentioned in Section 4.2.1 (e.g., Faisal and Al Moquattam). As a result, population density decreased consistently in that first period and then it started to increase steadily in the second period. Considering both students and employments, it is clear as mentioned earlier that both show a steady increase over the years in GC.

4.2.3 Brief on the evolution of population density categories and monthly household income levels 1986, 1996 and projected for 2022

The present section gives only a brief on the evolution of population density categories and household income levels in GC between 1986, 1996 and projected for 2022.

Table 1: Demographic features of GC in the governing years of the study*.

Year	1971	1978	1987	1998	2001
Urbanized Area(km ²)	160	206	254	NA	290
Population (million)	5.6	6.7	8.3	9.7	11.3
Density (pers/km ²)	35000	32524	32677	NA	38965
Employment (million)	NA	NA	1.7	3.4	NA
Students (million)	NA	1.6	2.4	3.7	4.0

* Based on references (8, 9, 10, 12 & 13)

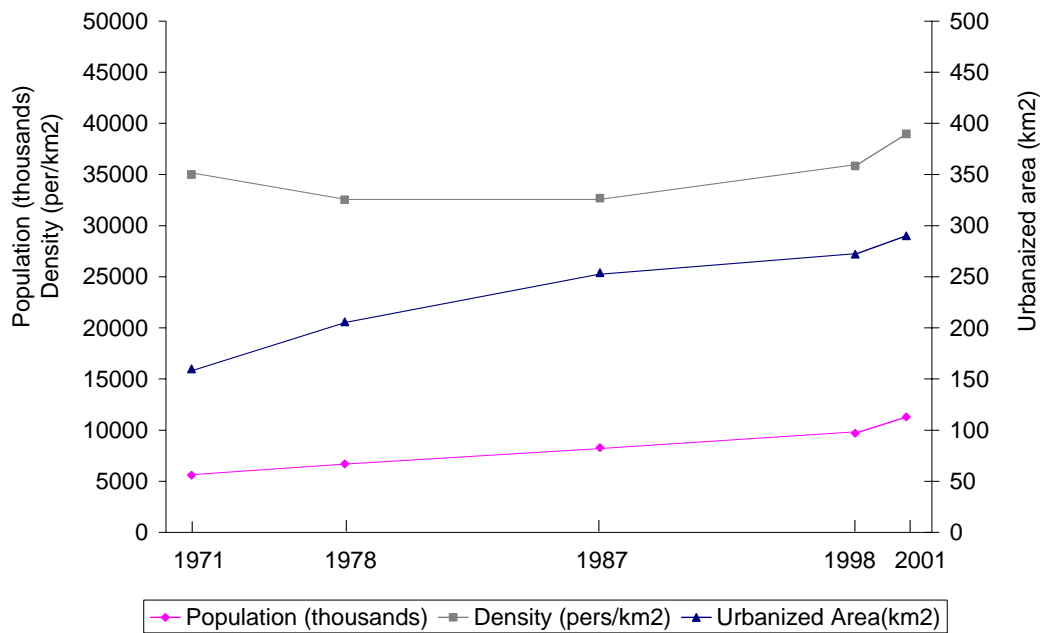


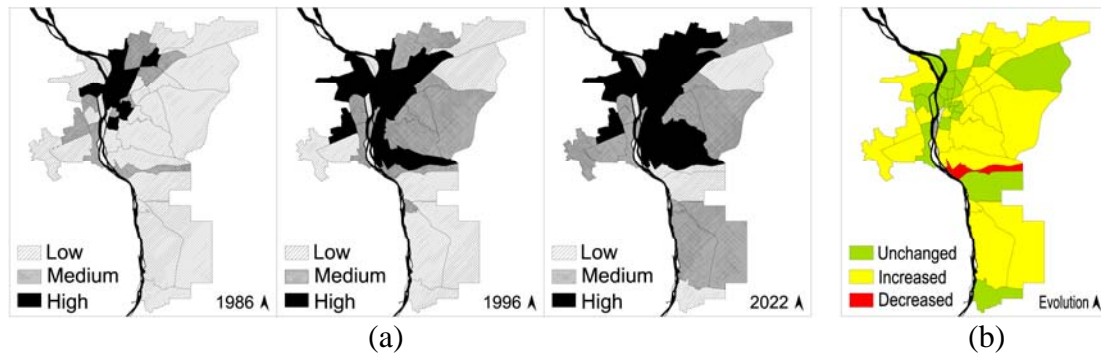
Figure 6: Evolution of Greater Cairo population, urbanized area and density in the governing years.

It is not intended to perform an in depth analysis of this topic as the available data is very generic and only allows a general picture of this evolution. Generally, many of GC administrative zones are witnessing more and more concentration in population. Figure 7(a) shows the evolution of GC population density categories (Low/Medium/High) in 1986, 1996 and projected for 2022, as the data for 2006 are not available. It is clear that the number of high population density administrative zones is increasing. In 1986, around 15 administrative zones were dense. In 1996, the number became 25 and is predicted to reach 28 zones by 2022. Most of these zones are around the core area of GC and on the western edge of it. Meanwhile, other zones that had low density levels turned to change to medium density levels. Figure 7(b) shows the evolution of population density categories over the years 1986, 1996 and projected for 2022. It is clear from this Figure that most of GC administrative zones are increasing in population density.

These zones are mainly located on the peripheries such as Al Waraq in the north, Al Ahram in the west and Madinat Nasr-2 in the east and Helwan in the south, or near to the core like Al Khalifa, Ain Shams and Madinat Nasr-1. On the other hand some zones remained unchanged in its population density. These zones can be divided into 2 categories:

- High urban population zones in the core area from 1986 such as Al Sayeda Zainab, Shoubra and Rod Al Farag. The saturation status of these zones makes it impossible to magnet more population as there are no more space to absorb more population.
- Low urban population zones such as Al Nozha and Al Zamalek. Special characteristics of these zones and special care from local authorities save them from the increase in population density.

Only one administrative zone that is predicted to witness decreased population density in 2022, namely Al Maadi to the south of GC. This maybe a result of the new extensions on the desert lands that is adjacent to the original urban area of Al Maadi accompanied with some restrictions from local authorities.



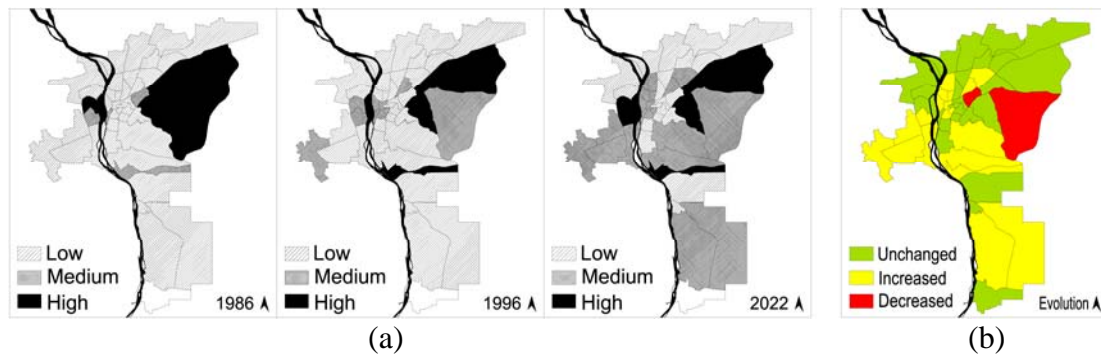
(a) Population density categories in each of the considered years.
(b) Evolution of population density categories 1986, 1996 to 2022.

Figure 7: Evolution of population density categories in Greater Cairo administrative zones; 1986, 1996 to 2022, (based on 14 & 15).

Figure 8(a) shows the evolution of monthly household income categories (Low/Medium/High) in GC; 1986, 1996 and projected 2022. The main changes took place from the low income level to medium income level. Many of administrative zones in GC especially those on the west/east corridor starting from Al Ahram in the west to Al Nozha in the east, and to other areas as Helwan and 15 May in the south. Actually high income level administrative zones are somehow unchanged along the period between the above mentioned three years, except Madinat Nasr-2 in the east, where it changed from upper income level to medium as it got some new extensions that are dedicated to youth and medium class families. It deserves to mention that some administrative zones in the core of GC remain in the low income level such as Al Dhaher, Al Gamaleya, Mansheyat Nasser and Al Zawya El Hamra. One of the main reasons is the poor urban fabric in these zones that impeded investments and establishing the needed infrastructure and services.

Figure 8(b) gives the evolution of monthly household income levels between 1986, 1996 and projected 2022, where it is clear that most increase in income levels from low to medium seems to be taking place mainly as follows:

- The western part of GC in Al Ahram, Al Omraneya, Giza, Al Dokki and Bulak El Dakrour.
- The southern part of GC in Helwan and 15 May.
- Other scattered locations near to core such as Al Zaitoun, Hadaeiq El kubba and Al Manial.
- Some decrease in income levels seems to be in Madinat Nasr-2 in the east and other district near it.



- (a) Monthly household income levels in each of the considered years.
- (b) Evolution of monthly household income levels 1986, 1996 to 2022.

Figure 8: Evolution of household monthly income levels in Greater Cairo administrative zones; 1986, 1996 to 2022, (based on 10 & 14).

Finally, Figure 9 shows a comparison of the evolution of the categories of population density and income levels in GC for 1986, 1996 and projected 2022 (data for 2006 are not available), where the following general comments are drawn.

- Some administrative zones can see increase in population density category (either from low to medium or high, or from medium to high, or the contrary), but unchanged income level. These are mainly located along the north peripheries of GC and in some locations near to the core. For those zones with low income level, the low cost of services, even with low quality, encourages the low income newcomers to reside over there. For the middle income zones, however, because of the existence of some vacant land, some additional middle income families can be absorbed.
- Some other zones are witnessing no change in both population density categories and income levels because they are either fully saturated or have special features such as: having fixed activities, e.g., embassies, hotels, sporting clubs, etc., or the land value is very high, etc.
- Some administrative zones may see increase in both population density categories and income levels as well. These are in the west of GC as Al Ahram, Al Omraneya, Bulak El Dakrour and Al Dokki districts and in the south of GC as Helwan and 15 May.
- Al Maadi is a special case with an increase of income level with a population density decrease, and with some social changes.

4.2.4 Evolution of activity concentration and decentralization

Most of the main activity centers in GC were concentrated in central area, particularly the traditional CBD surrounded by three major squares, Al Tahrir, Ramses and Al Attaba, that was created with its beautiful architectural style of the 19th century during the rule of Khedive Ismail between 1863 and 1879. The CBD activities saw expanding evolution ever since including small shopping boutiques and department stores, restaurants, theaters and cinemas, hotels, travel agents, airline bureaus, banks, private clinics, other diversity of business offices and some ministries and governmental agencies. Later after the end of World War II and the increased use of the private car, taxis and public transport buses as well as increased tourism and improved economy, the CBD started to practice congested traffic, not only during business hours but also in the evenings for night shopping, recreation activities, visiting late night clinics and others. It is reported, for example, that in the late 1970s some 140000 workers were employed as sales assistants in CBD shops (16).

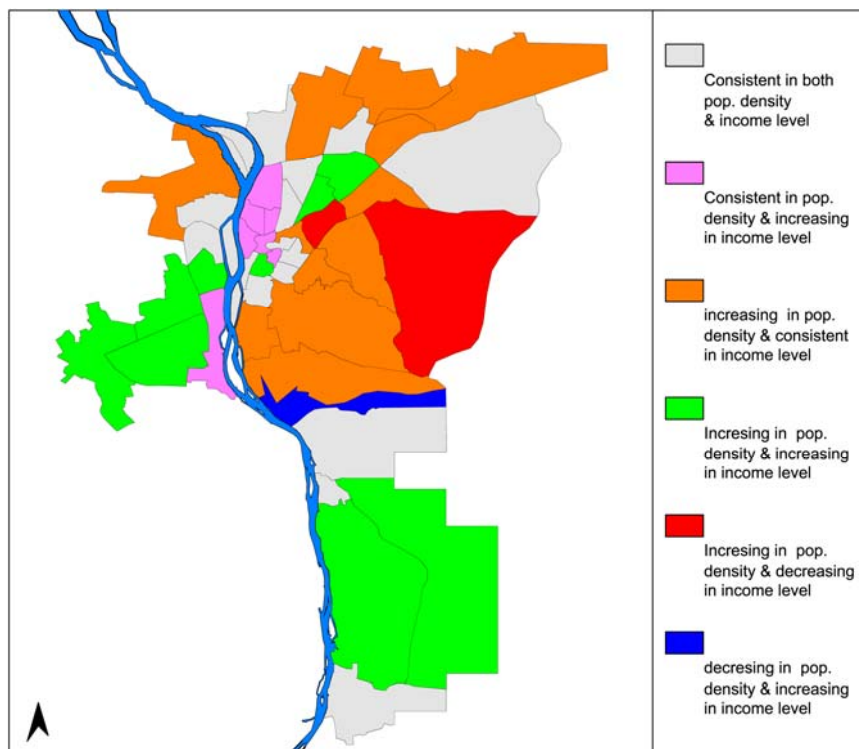


Figure 9: Comparison of the evolution of the categories of population density and income levels in Greater Cairo for 1986, 1996 and projected 2022.

Gradually since the late 1970s and early 1980s, decentralization of activities started to take place. The aim was to escape the congested down town streets and hence better business can even be achieved due to ease of access to other parts. Soon afterwards new activity centers appeared in Roxi and Helipolis in the north, Madinat Nasr in the north east, Giza in the south west, Al Zamalek and Al Mohandesseen in the west of the CBD and Emarat El Oboor in the north east.

Those included in the beginning private businesses, banks, travel agencies and shopping boutiques and later public sector department stores and government banks and other business offices followed suit. These provided shopping and other opportunities for residents of all income levels. In addition, it relatively released traffic congestion in the CBD and along the corridors leading to it. Many people found it convenient to visit the new activity centers that became more accessible to their homes. Later in 1990s and the early 2000s the new cities started to develop services centers that contain important commercial malls and attractive recreational activities. These centers helped to relieve some pressures from other inner centers.

Besides, new private Universities and educational institutes were established in the new cities attracting many students, offering new opportunities out of the four government Universities located in GC. A number of trials have been made to relocate some of the ministries and government offices from Cairo CBD to the new cities. These have always suffered from the reluctance of the employees to move after being settled for long in the old city. Nevertheless, these efforts are still being made. Recently, the government has successfully developed a planned office site near the toll gates of Cairo Alexandria Desert Road, namely the "Smart Village", which houses many private Information Technology related businesses as well as the new offices of the Ministry of Information Technology and Communications that moved from the central location in the city and some of the main offices of the Cabinet.

4.3 Evolution of Informal Housing and the New Cities around Greater Cairo

4.3.1 Informal housing; evolution, problems and remedy policies

Like many of the highly populated metropolises of the developing countries, informal random expansion in the peripheries of GC started to take place unnoticeably in a gradual fashion of urban sprawl. The start was mainly in the 1970s. Informal housing emerged with mainly poor families starting, unnoticed one after the other, to violate agriculture regulations that forbid building on farm lands. This is believed to have resulted from the increased migration, from the rural countryside to the capital that took place, never as before, between the mid 1950s and through to the late 1960s, as mentioned above. Thousands of rural residents came to Cairo over those 15 years for better life conditions and promising job opportunities that in many instances did not necessitate skills or experience, e.g., care takers of houses, distribution of bread and news papers, cleaning of streets, parking garage wardens, etc. In absences of suitable low cost housing units and lack of fund, migrants started to establish their own homes on small areas of vacant or mainly agricultural lands at the periphery of Cairo. Later, in the 1970s many of the low middle class families noticed and started to violate the regulations; building three to five floor housing units on the peripheries as well.

Most of these informal settlements are located in the following districts of GC:

- In the northern part: Al Marg, Shoubra Al Khima-1 and Shoubra Al Khima-2 districts.
- In the western part: Al Waraq, Bulak El Dakrou, Al Ahram and Al Omraneya districts.
- In the central part: Mansheyet Naser and Al Basateen districts.
- In the southern part: Al Masara district.

The main faced problems include the poor structure of the urban fabric, the difficulty to provide sufficient infrastructure, the insufficient commercial services, and the lack of ample sport, culture and recreation centers. The very high density of housing units makes it very difficult to provide decent roads and space for public transport and goods vehicles serving the commercial units. These problems have also their bearing on other neighboring districts including mainly sharing the services and hence creating over use of the supply and transfer of some social problems.

After the peace era in the late 1970s, the government started to pay attention to national development. Of course GC accommodating the capital of the state got major part of this attention. One of the main challenges facing the future of GC was those informal settlements that were rapidly swelling during this period. So, the concerned local authorities started three main policies to deal with the problem as summarized below.

One policy starting in the 1980s, calls for the removal of the settlement and transferring residents to new planned housing projects in new planned urban areas, providing the needed land uses and services. An early example of successful implementation of this policy is the removal of Arab El Mohammady informal housing located in the northern fringe of central Cairo to Madinat El Salam and Madinat El Nahda in the north east of GC with new well planned housing. The new locations were also favored by the moving families because they were closer to the places of work of most of them compared to the original old site. The latter was converted into a beautiful garden, where a public library was built to serve the local community in the surrounding area and other GC residents as well. Figure 10 shows another example of a removed settlement, namely Eshash Teraat El Ismailia in the northern part of GC where this policy was also applied and residents moved to the above mentioned well planned housing projects in Madinat El Salam and Madinat El Nahda, where the original land was converted into a park and recreational area.



Before renovation



After renovation

Figure 10: Location of Eshash Teraat El Ismailia before and after removal of the informal housing and renovation, (17).

The second policy is to re-plan the random settlement, rebuilding its residential units and providing the needed services and infrastructure. In this case, people are temporarily moved to other residential areas; then reside them again in their original settlement after renovations.

An example is shown in Figure 11, where Zeinhum informal settlement in the southern fringe of central Cairo was subject to re-planning over a 5 year period during which temporary re-allocation of residents took place.

After some pilots, it appeared that the first and the second policies were suitable for the scattered informal settlements with small population and small area and not for those with large areas and high population densities occupying stacked locations on GC peripheries. Different treatment had to be sought. So, the third policy that calls for the development and enhancement of the structure of the informal settlements as much as possible was implemented in many parts of those settlements. An example is Bulak El Dakroul in the western part of GC (17). The enhancement includes provision of infrastructure and planned services.



Figure 11: Zeinhum informal housing settlement before and after renovation, (17).

4.3.2 The New Cities; evolution of a pioneer experience on the desert

Considering the general status of GC during the 1970s, with very high concentration of population and other activities expanding over the agriculture farm land in the periphery, the government adopted in the late 1970s a pioneer new urban development policy upon the initiative of the late President Sadat calling for planning and building new cities on the desert lands in Egypt. Some of these new cities were located around GC. Other cities were located in both Upper and Lower Egypt; but mainly the latter. The main target of these cities is to replace random expansion over agriculture land to planned new communities on the desert. Additional important objectives are to absorb major portions of activities of population and investments from the over-saturated adjacent existing urban areas and to absorb population growth and furnish new opportunists for young families. The overall eventual goal is enhancing the quality of life in the new and the existing cites and the country at large. A very early call for sustainable development well before the notion emerged in the late 1980s.

For the cities around GC, the start was with the New Cities of 6 Oct. in the west, 10 Ramadan in the north east and 15 May in the south. These three new cities are planned to house around 1.25 million inhabitants. The government took all planning and infrastructure provision and played the major role in the development process. Another group of new cities followed afterwards as planned. These include Badr, Al Oboor, and Al Shorooq Cities.

In the 1990s delay was noticed in the development of housing contrary to the overwhelming industrial development that successfully took place, particularly in 6 Oct., 10 Ramadan and, to a smaller extent in, Al Oboor cities. As a result, development policies were changed to give the private sector major role to play in the development processes. High income housing and services got more attention. However, in parallel major schemes for youth housing to accommodate low and middle income young families took place as well. Hence, many housing and services projects were established. Today, it seems that the latter policies succeeded somehow to achieve more housing developments in these cities in order to cope with the industrial development trends. However, still more internal services are needed in some districts of the new cities in order to increase attractiveness. This is in addition to introducing dynamic innovative housing policies as explained in reference (18). Table 2 gives the type and 2006 population of the 8 new cities around GC and Figure 12 shows the location of those new cities around GC. Further details are out of the scope of the current study.

Finally, by all means and without any doubt the experience of the new cities in Egypt is a pioneer and unique successful experience, bearing in mind the cost and the technical and social difficulties involved to make this dream a reality. It is reported (20), for example, that the urban expansion of Cairo is very impressive and probably there is not a larger urban building site in the world today as that one; and that the new cities around GC are likely to be the second most extensive in the world, after Hong Kong. The above mentioned difficulties include, but not limited to, those related to infrastructure provision and building construction on desert sandy soils, the difficulties of providing water supplies and in combating desert environment and climate problems and the difficulty of convincing residents of the existing old cities in the Delta and around the valley of the River Nile after settling over there for 7000 years, to move to the new communities. All over the country there are now 21 new cities in operation under various stages of development and all are located on the desert. Massive industrial development is successfully offered with numerous industrial firms operating since the 1980s and contributing considerably to the national economy and the employment market.

Table 2: Type and 2006 population of the new cities around Greater Cairo, (19).

City	City Type	Population 2006
6 October	Industrial	500,000
Al Sheikh Zayed	Residential	48,000
15 May	Industrial	180,000
Al Oboor	Industrial	100,000
Badr	Industrial	60,000
Al Shorooq	Residential	62,000
New Cairo	Residential	302,000
10 Ramadan	Industrial	500,000

In a country that has over 75 million inhabitants living merely on 4% of its area, it is inevitable and sustainable enough to move for living on at least some of the remaining 96% of desert land. This is the future that Egypt has been planning for since the late 1970s.

4.4 The Current Urban Structure of Greater Cairo

At the turn of the 21st century, GC started to get its contemporary structure as a "main dense urban area" with varied socioeconomic levels encircled by the Ring Road and an "outer belt" of 8 new satellite cities as shown in Figures 12 and 13. The main dense area can be further sub-divided into a "core area" and a "surrounding peripheries".

The "core area" is the historical part of Cairo. It includes the original CBD "Khedival Cairo" of the late 18th century and "Islamic Cairo" of the more historic era of the 5th century. Major activities are still settled in this core like government agencies, commercial activities, wholesale and retail. This core is characterized by population concentration and high densities. Although it has distinctive urban fabric, known to have an "Islamic and Khedival urban and architectural" style, yet to somehow this fabric turned out not to be currently suitable because of the huge concentration of population and activities. Also it is not compatible with the provision of appropriate public transportation and parking facilities.

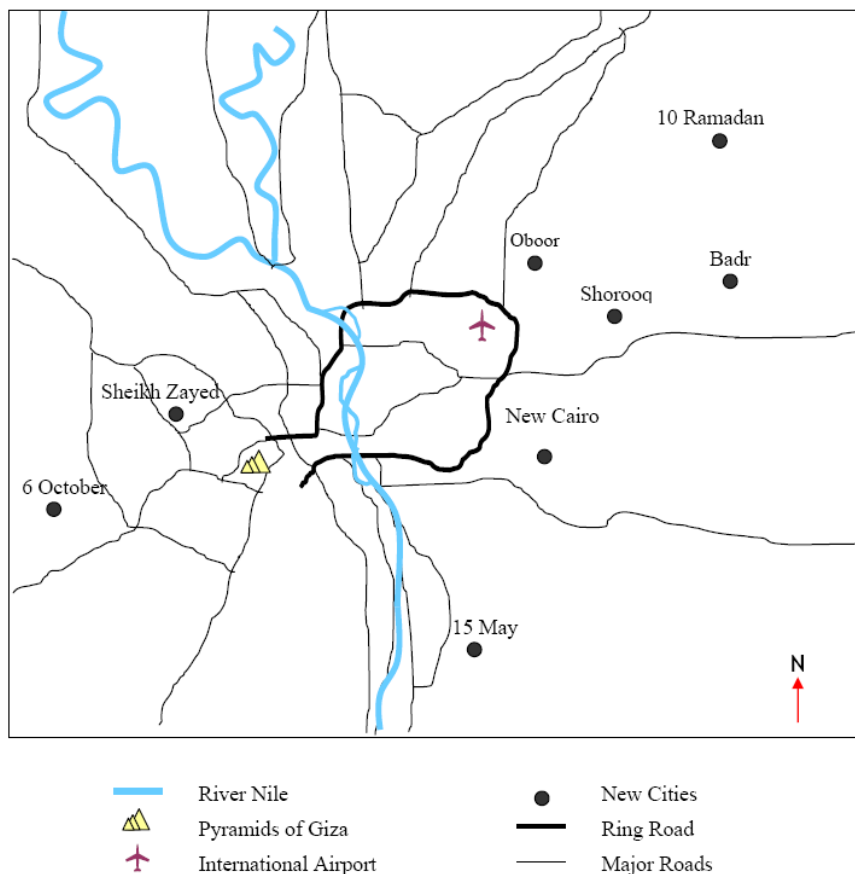
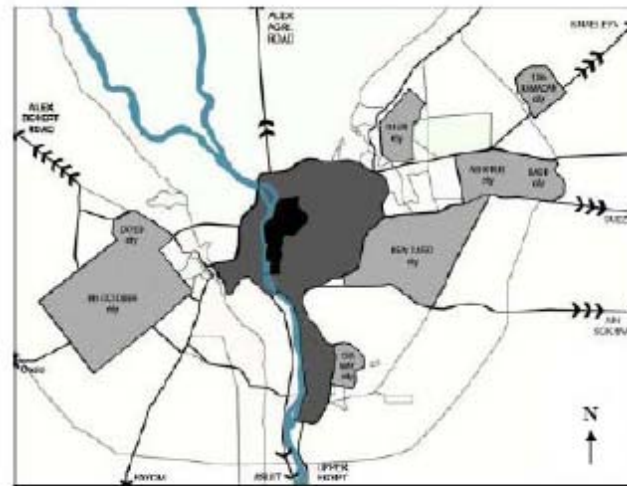


Figure 12: Location of the new cities around Greater Cairo.



■ "core area" ■ "surrounding peripheries" ■ "outer belt"

NB: The number of arrows presents the extent of development on the 6 development corridors.

Figure 13: Current structure of Greater Cairo and the development corridors.

The "surrounding peripheries" of the core area of GC contains a group of planned areas and a group of informal settlements. The two groups date back to the 20th century, when the planned areas of this zone, containing new sub-centers, emerging in the 1950s, with varied activities. For example, new major government agencies built in Madinat Nasr and new commercial and entertainment activities in Al Mohandesseen. These areas are characterized by moderate to high densities. On the other hand, the informal settlements of the second zone facing many challenges as mentioned earlier. Examples, are Saft El Labn, Nahia and Dar El Salam. Both the core and the surrounding peripheries of the main urban area of GC houses major portion of GC population and activities.

During the last 15 years of the 20th century, GC started to develop the "outer belt" of 8 new cities combined with a group of other urban development and real estate projects; currently all at different stages of development as mentioned earlier. Notable urban development has been in progress especially across six of the major 13 regional corridors leading to GC. With the main attention directed to settle a number of important urban development and real estate, industrial estate projects and agriculture development. These corridors are Cairo Alexandria Desert Road, Cairo Alexandria Agricultural Road, Cairo Suez Road, Cairo Ein El Sokhna Road, Cairo Assiut Road and Cairo Ismailia Road. The volume of investments and development projects on the corridors are varied as a result of different factors.

Obviously, the most important and active corridor is Cairo Alexandria Desert Road with the highest concentration of activities in both cities. It links the two major urban areas in the country passing through the desert and hence large vacant lands are available both sides. As a result the land value is low enough to encourage activities that need large areas. In addition it links to Alexandria Port which encouraged many investors. The three corridors linking GC with the secondary cities of Ismailiya, Suez and Ein El Sokhna have moderate development projects compared to the former corridor. However, they still have good opportunities for future expansion. The remaining two corridors have small development activities. These are the corridor of Cairo Alexandria Agriculture Road and the corridor of Cairo Assiut Road. The former passes through the Nile Delta and the latter through the Nile Valley with fertile lands along both sides and/or difficult development conditions.

Figure 13 shows the three main zones of GC and the main regional development corridors. Note that the number of "arrows" indicated on each corridor in the Figure reflects the volume of development activities on the corridor.

5. Transport

5.1 Introductory

In view of the continuous urban expansion and population growth of Cairo and later GC and as a consequence of the related development drivers, the evolution of "transport needs" of the residents, and visitors alike, and that of the "offered transport facilities" have always been increasing. As there are obvious problems of congested corridors and traffic delay and of crowded buses during peak hours, there are also successes and achievements of major infrastructure projects of new elevated roads, parking garages, improved buses and metro network expansion. Similarly, on the other hand for the outputs, as there have been continued increase in energy consumption from transport and deterioration in air quality and increased greenhouse gas emissions due to transport, there are in the same time projects and policies aiming at saving energy and the introduction and/or encouragement of environmentally friendly fuels and transportation. Examples are many; including the first metro in a city in Africa and the Middle East successfully operating since 1987 and continuously expanding ever since, the Ring Road of some 100 km since 1990s, massive use of CNG in taxis since early 1990s and the expansion of the International Airport in two successive periods in the mid 1980s and mid 2000s, when the need so dictated.

Therefore, "transportation" is in the middle, between "urbanization" from one hand and "energy/environment" from the other; taking the burden of the expansion of the former as a driver of increased demand and supply, and evolution by size and location, and causing impacts on the latter, also by size and location! In the current Section of the report we try to analyse the evolution of transport in GC over the years as a consequence of urban development and population growth, analysed in Section 4, and as input to the consequences on energy and environment, as analysed in Section 6.

5.2 Greater Cairo Transportation at Present

Figure 14 shows the main road network of the GC region in general covering the new cities and the surrounding urban centers, whereas Figure 15 shows the main road network of GC inside the Ring Road boundaries on which the present study is based (see Section 2). The road network is composed of a variety of road hierarchy ranging from elevated expressways forming strategic traffic corridors, other major expressways, major and minor arterials, collector streets and local streets, in addition to numerous alleys in the old districts. A Ring Road of some 100 km also exists and prevents through traffic from crossing the city. The River Nile passes through the city from the South to the North, and constitutes a major geographical barrier between the East Side and the West Side Districts of GC. Sixteen bridges cross the River and play important role in connecting the two sides of the mighty River and the islands. Numerous flyovers exist, by-passing main squares and road intersections as well as the tracks of the two metro lines along their "above-the-ground" sections, in addition to a number of underpasses that facilitate traffic flows at a number of main squares. Furthermore, a number of main traffic tunnels are heavily used; two of which are 2.5 km length each, under-passing Old Cairo in both directions connecting the CBD with Salah Salem major expressway that extends to Cairo International Airport via Al Oroba Expressway. Though many off street parking lots are located in many districts of GC, yet they are not enough to absorb the demand on parking. A number of multi-storey and underground car parks also exist. On street parking is allowed on many streets except in front of major land use units as hospitals, schools, banks, Embassies, etc. These are only metered in the CBD and monitored by individual licensed attendants in other districts, they are, however, free of charge in many of the residential and non-central districts and along side streets. Illegal parking is patrolled by traffic police, utilizing the usual mechanical equipment for violating vehicles, particularly along major corridors and in central areas, with heavy fines applied as well.

Among the existing private transport modes, the private car is the most important; while among public transport, different modes play important roles as discussed later. Different models of private cars run on GC street network, mainly European, Korean and Japanese. No statistics are available on age distribution of private cars. However, it is observed that though many new models of the first decade of the 21st century exist, still cars of the late 1970s, 1980s and 1990s models are observed as well. Other private transport modes include mainly private bus, tourist bus, school bus and "own account" buses run by different agencies for the transport of own employees. It is interesting to observe that the number of motorcycles is small compared to other modes and mainly compared to their use in some Asian cities, which is in favor of air quality and reduced greenhouse gases as well as safety. Below are some of the published car and motor cycle registration for 2007, (11).

As mentioned earlier till the early 2008, GC region was composed of Cairo Governorate and only the urban parts of Giza and Qalubia Governorates. So, if we combine the number of registered cars in the above three governorates, this would always be more than the value for GC. The given values for GC private cars in previous studies and reports are, therefore, always estimates and not authorized records.

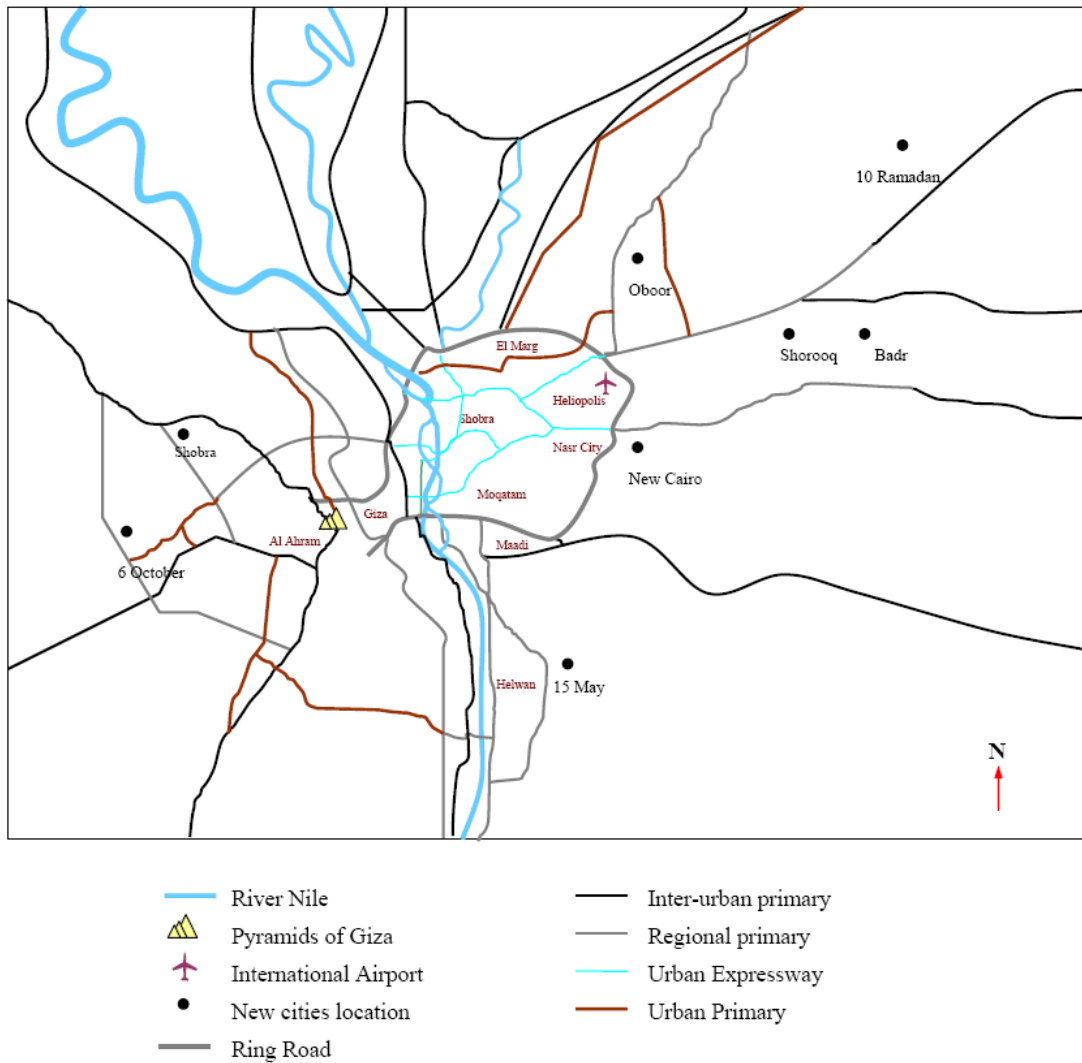


Figure 14: Greater Cairo Region main road network, (based on 10).

The concentration of private cars in the above three governorates is remarkable compared to the remaining governorates as it reached 1328712 cars in 2007; about 31% of a total of 4.25 million vehicles (private cars and other vehicles combined) in the country in that year. The registered private cars for Cairo Governorate alone in 2007 reached about 960150 cars, which is about 23% of the above mentioned all vehicle registration in Egypt and 70% of all vehicle registration in Cairo Governorate. In 2007 the registered motor cycles in the above three governorates reached 265481 about 33% of the country total in that year. The registered motor cycles in Cairo Governorate alone in 2007 are 138437 motor cycles, which is about 17% of the total motor cycles in Egypt and only 10% of all vehicles registered in Cairo Governorate. As mentioned earlier the values given above are based on (11).

As for the taxis; three types exist. The ordinary taxi, black and white colored cabs, which though metered, yet they are used for commonly known fares that change with the traveled distance and voluntary increase from time to time. The age of taxi vehicles is mainly old as many are made in the 1970s and 1980s. However, also many of the 1990s and very few 2000s models are also observed. Efforts for replacement of old taxi cabs started lately as explained in Section 8. The other type of taxi is the yellow color cabs formally known as "Taxi of the Capital" and commercially known as "City Cab" and "Cairo Cab", operated by two private companies. All vehicles are of 2006 and 2007 models, air conditioned and fitted with digital meters. Drivers issue receipts of payment, and one can order a ride by a phone call to the companies' Call Center connecting to the operations customer service. The fees are slightly higher than what is paid for the same trip on the ordinary taxis. However, for long trips they are much cheaper. The contract with the three governorates of GC signed late 2005 necessitates total renewal of the fleet every five years to keep the high level of service and to preserve air quality. According to recent company statistics, 470 cabs are in operation in 2008 and 300 more entered the service in December 2008.

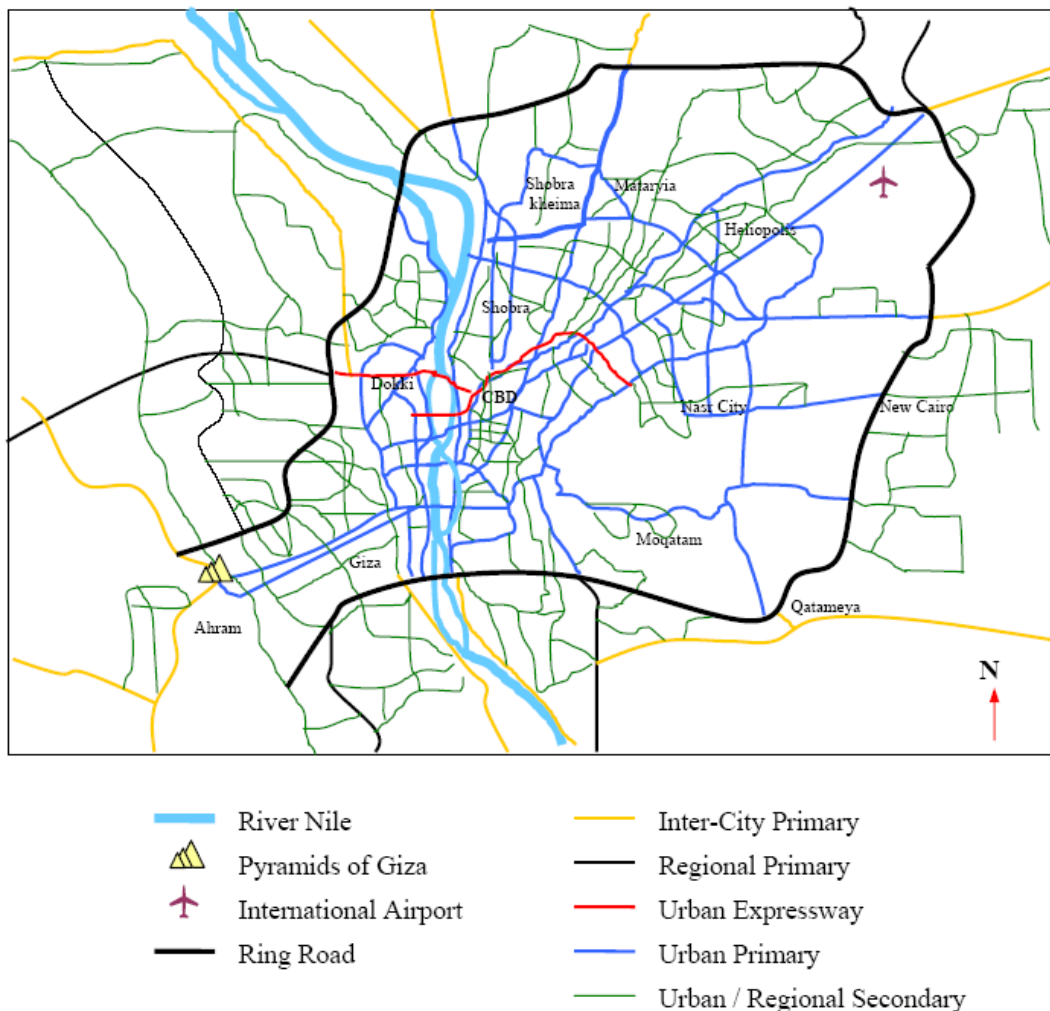


Figure 15: Greater Cairo main road network inside the Ring Road, (based on 10)

The third type of taxi is the black "limousine taxis" operated by private companies and run services mainly to Airport and other central destinations and major hotels and can be also called by phone through the operating companies. Fares are set in advance and advertised according to the destination and they are more expensive than the other two types of taxi. In 2007 the registered taxis in the governorates of Cairo, Giza and Qalubia reached 120214 about 39% of a total of 309748 in the country in that year. The registered taxis in Cairo Governorate alone in 2007 is 71376 taxis, which is about 23% of the total taxis in Egypt and 5% of all vehicles registered in Cairo Governorate. As mentioned above these values are based on reference (11) and the above numbers includes shared taxis and intercity taxis as well.

Public transport consists of formal and informal modes. The formal modes include: bus and minibus (25 seats) of Cairo Transport Authority (CTA), bus of Greater Cairo Bus Company (GCBC) and minibuses of a number of private companies. The network of buses and minibuses is more than 10000 km in length based on 2001 CTA statistics. The GCBC operates buses mainly on long length peripheral routes. Whereas, the CTA bus lines mainly operate on radial corridors serving outer districts in inner Cairo, in and around the CBD. A number of private companies operate minibuses on concession lines monitored by CTA within Cairo Governorate and by Giza Governorate on its territories of GC. The number of registered public transport buses including intercity buses in the three governorates Cairo, Giza and Qalubia reached 7636 in 2007, of which 6625 are registered in Cairo Governorate (11).

In addition, CTA runs two tram systems, namely Heliopolis metro covering the mainly residential districts Heliopolis and Madinat Nasr in the North East of GC and the tramways on some northern lines in Cairo and 15 May City in the south. The system is now poorly used compared to other formal transit modes. The tram system of Cairo has a long history, though it is gradually declining since the 1950s. Based on reference (21), the start was in 1908; four years after the tram of Alexandria was electrified in 1904. It is interesting to note that Alexandria tramway was opened in 1862 on a 6 km track as a horse driven line; and one year later in 1863 a steam engine tram started to operate on the same track. The 1908 tram was introduced to serve the residents of Cairo and Giza and in 1910 Heliopolis Metro tram lines were introduced to internally serve the, then newly established, residential development district "Misr Al Gadida" (Heliopolis) and to link it with Cairo CBD. However, a recent project of a modern LRT super tram line is planned between north east Cairo and "New Cairo"; one of the new satellite residential developments around GC. Finally, CTA runs two Nile ferry lines.

The latest but by far the most effective formal public transport mode in GC is the metro, with a network of some 80 km; Lines 1 and 2 inaugurated in 1987 and 1996, respectively. Phases I and II of Line 3 are under construction and due for opening in 2010 and 2013, respectively. Lately the Cabinet confirmed the start of the feasibility study, design and preparation of tender documents of Phase III of Line 3 and Phase I of Line 4, so as implementation can start simultaneously in those two new Phases immediately after the beginning of operation of Phase I and Phase II of Line 3.

The metro is operated by the Egyptian Company for Metro Operation and Maintenance (ECM) which belongs to the Ministry of Transport.

Public transport informal modes are the shared taxi microbus (mostly 11-seaters) and the cooperatives minibus (mostly 25-seaters). Benefiting from the small size and being operated by individual drivers/owners, the shared taxis are heavily used as discussed later, practically for feeding metro stations from remote areas and serving many of the informal housing areas. They are operated on licensed routes authorized jointly by the local authorities of the governorates of GC and the relevant traffic police departments; each on its territories. However, the CTA is taking charge of the overall responsibility of route licensing of the shared taxis within Cairo Governorate. Generally since shared taxis are demand responsive, some route violation exists. Cooperative societies run informal minibuses and mainly link rural centers and villages around the peripheries of GC with some of the inner parts and mainly operate in the Giza part of GC.

The most important NMT (non-motorized transport) is walk as only very few trips are made on bicycles, contrary to the secondary cities in Egypt where bicycles are heavily used. Perhaps the reason is the long travel distances in GC, as well as the heavy vehicular traffic and the narrow streets with no dedicated lanes for bicycles; which make cycling inconvenient, uncomfortable and also unsafe on some streets.

5.3 Current Institutional Set Up and a Brief on Transport Financing

Highlights on the institutional set up of GC transportation: Similar to other mega cities, many agencies are involved in transport policy decision, operation and monitoring. First, GC is shared not only by the three Governorates mentioned above, but in early 2008 two more were introduced, as explained in Section 2. Each governorate has its legislative elected council thorough which decisions should be approved including those related to transport. In addition each governorate has its own local technical Directorate of Roads and Transport, and own Traffic Police Department. The former is mainly responsible of street maintenance. Cairo Governorate has a Traffic Engineering Bureau (CTEB), responsible mainly of issuing licenses of new land use activity units from the point of view of the impact on traffic and approving any new off street parking facilities (parking lots and garages) and traffic management schemes. Traffic Police Departments in each governorate is of course responsible of issuing driver and vehicle licenses in the first place. They also obviously take charge of enforcing traffic law, monitor and control the application on the ground, mainly at street intersections with traffic signals and along main streets where on street parking is prohibited and they participate in the approval of traffic management schemes as monitoring the application is their responsibility. Besides, the General Directorate of Traffic is responsible of the major national roads between cities and regions. Therefore, it is responsible of all the traffic police duties mentioned above but along the sections of the national roads that pass on the territories of GC, including those of the 13 major corridors linking CG with the other cities in the north, south, east and west.

Cairo Governorate is responsible of CTA even if their bus network covers the whole area of GC running on the territories of the other GC governorates. A number of private companies are responsible of operation of the concession lines of minibuses under the supervision of CTA for the lines operating in Cairo Governorate. The concession lines in Giza are contracted through Giza Governorate, however. Each governorate is involved in licensing shared taxi routes operating from their territories together with the respective traffic police departments. However, as mentioned earlier licensing of shared taxi routes in Cairo Governorate are under the responsibility of CTA. The yellow taxis are under the ownership and operation of two private companies, while the Union of Taxi Drivers is involved in the drivers' issues of the other ordinary taxis. Each of the governorates of GC is responsible of licensing the yellow taxi companies and renewal of their contracts. The local authority of each governorate is also responsible of operating parking lots and shared taxi terminals inside their boundaries. The metro is belonging to the Ministry of Transport through ECM and the suburban rail lines belong to, and operated by, Egypt National Railways (ENR) which is obviously belonging to the Ministry of Transport as well.

The Ministry of Housing and Urban Development is heavily involved in the construction of elevated expressways before transferring operation and ownership to the General Authority for Roads, Bridges and Land Transport (GARBLT) of the Ministry of Transport; as happened lately in the case of the Ring Road, for example. Recently in February 2009 GARBLT completed a feasibility study of urban toll expressways for possible PPP tendering. However, decision on implementation is still to be investigated. Until recently Al Azhar two traffic tunnels (2.5 km each) were operated by the National Authority of Tunnels (NAT), under which the tunnels were constructed, when operation was transferred to the owner, Cairo Governorate, in 2008. NAT is responsible of all tunneling projects in the country and mainly the metro tunnels in GC. Currently NAT is taking charge of monitoring the contractors of the construction of Phase I and Phase II of metro Line 3. However, after construction, the metro lines are always immediately transferred from NAT to ECM for operation and maintenance as NAT is not an operator. Environmental concerns are in hand of the Ministry of State for Environmental Affairs through EEAA (Egyptian Environmental Affairs Agency). Decision on transport, and other, projects within each governorate are to be approved by the elected Local Councils of each governorate. Finally the Cabinet is responsible of decisions on national projects as the GC metro and major elevated expressway and traffic tunnels and the Peoples Assembly (Parliament) should approve such projects. Finally, the Ministry of Economic Development is responsible of budget allocation to major projects including those related to transport and the Ministry of Finance is responsible of the allocation of subsidies including those directed to public transport.

Brief on financing: As mentioned above, CTA is operated and administered under the Cairo Governorate general direction. The Governor of Cairo is the Chair of its General Assembly. However it has full autonomy under a full time Chairman and own General Council. It is partially financed from fare revenues and partially by the national budget as it receives annual subsidies in order to be able to keep fare values affordable and to keep a reasonably acceptable, but not superior, level of service.

However, CTA also runs some profitable services at high fare values as the Air Conditioned Bus and the Express Lines which cross subsidise the regular lines. Fare values of the private minibus concession lines are slightly higher than those of CTA and are decided in the concession contracts. The companies are asked to offer a balanced service; covering profitable lines and other lines; for the benefit of the users and also to complement CTA services. However, in general these companies have profitable financial performance and are not entitled to any kind of subsidy.

Shared Taxis are self financed by the owners/drivers, generate profitable revenues and do not receive any subsidy except if we consider the subsidized price of fuel that is generic to all modes. The fares on the licensed routes are decided by the local authorities for the governorates of GC; except in the case of Cairo Governorate as this is the responsibility of CTA. However, in some occasions fare violation occurs by drivers, irrespective of the big effort of monitoring by the local authorities. Yellow taxi cabs are under full responsibility of the owner/operator companies but of course are licensed and regulated by the governorates of GC, which negotiate the fares and the companies and drivers strictly observe with hardly any noticed violation. This service is profitable and cover operating cost and the operating companies do not receive any subsidy.

As mentioned above the metro belongs to, and is financed by, the Ministry of Transport and was since the opening of Line 1 in 1987 till 2006 under full authority of Egypt National Railway (ENR) as one of its divisions. In 2008 ECM took charge of operation and maintenance as a separate public company belonging to the Ministry of Transport and totally separated from ENR, having its own budget. Financing metro construction was through a French loan for Line 1. Financing the construction of Line 2 was totally undertaken by the Ministry of Transport and Telecommunications; luckily enough through the telephone bill. Since 2000 the Ministry of Telecommunications is separated from the Ministry of Transport and, hence, Line 3 Phase I financing is arranged through loans from France and Japan. Financing operation comes from the fare box in addition to annual subsidy from the national budget so as to keep fares affordable. It is important to note that the metro offers three months seasonal ticket for reduced price compared to single tickets equivalent. Many of the industrial companies in Helwan around the southern section of Line 1 offer the three months pass to their workers as part of the social incentives schemes. In addition, a student pass valid only during the school and University academic terms is on offer at a very reasonable price.

As far as parking facilities are concerned; most of the parking lots belong to, and operated by, the local authorities of the GC three governorates (now five), each on its territory. Some others are privately owned and operated. On street facilities in the CBD are metered via smart cards and operated by a private concession company through the Cairo Governorate local authority. The parking fees are increased from time to time and cover the operation and maintenance cost of those facilities as well as generating annual profits.

On street parking in other districts is either free of charge or operated by individual licensed attendants who assist the drivers in parking manoeuvrability and guard the parked cars, for a nominal fee. However, the local authorities also operate on street parking facilities along a number of the main streets. As for multi-storey car parks and underground garages, they are owned and operated by private enterprises and licensed by the governorates, which authorize the fees in a balanced way that are affordable and also profitable to operators as no subsidy is applicable at all.

Efforts of institutional coordination: Since 1987 (22), the creation of an institutional mother agency to cater for coordination of public transport in GC was first emphasized and presented giving a practical framework for immediate creation. This is reiterated again in many subsequent studies, in the 1990s and 2000s, (e.g., 10, 23 & 24), some of which called also for expanded planning and supervisory role for all transport services in GC and not only public transport. Recently, in the mid 2008 a new effort is launched in which a committee is formed to suggest ways to coordinate GC transport, and seems to be concentrating on public transport. The report of the committee is not yet published, however.

Irrespective of these repeated calls and efforts, it has been always very difficult to create a coordinating agency. What makes the decision externally complex is particularly the fact that the above mentioned multiple agencies that need to be coordinated under a single supervisory entity, belong to many authoritative institutions. For instance, a number of these agencies belong to a number of ministries and there are also five governorates; each with a number of own local agencies and legislative elected councils. CTA and ECM are also important giant players in GC public transport market. In addition, the Cabinet and the Peoples Assembly (Parliament) are involved in major transport projects decisions and approvals as mentioned earlier. Furthermore, a number of private companies are also involved in public transport concession lines and the yellow taxi. Individual drivers/operators are of course dominating the very heavily used shared taxi and ordinary taxi operation and a number of cooperative societies run informal minibus shared services as mentioned in the previous section.

It is strongly believed, therefore, that in view of the above realities, it is a very complex task for any unified mother entity (even if it is formed) to perform efficiently in such a huge mixed-authority work environment. Maybe, therefore, a coordinated effort between these agencies and operators with a spirit of understanding and cooperation, guided by top level decisions, could be a better realistic and pragmatic alternative. The effort and energy spent to call for the creation of the mother agency, as happened over the past 20 years, is better directed, and strongly recommended, to be invested in a drive to create a practical mechanism for the above mentioned coordination effort to be achieved, which still not easy to reach. However, this issue is out of the scope and the objectives of the present study.

5.4 Previous Major Transport Studies and Surveys and the Governing Years of the Present Research

Over the past 40 years, a number of transport studies and surveys were carried out in GC; each with own objective and, hence, size, features and deliverables. For instance, the first Origin/Destination Home Interview Study and Survey was performed in the late 1960s as a part of a research effort initiated by a Minister of Transport of the time. However, we possess very limited traces of the results, though it was computerized and considered as a pioneer professional effort indeed. Later, five other major transport studies followed, with varied levels of availability of the outcome. These studies undertook passenger transport demand surveys and reported information on transport supply of the time with varying level of detail according to the objective and the budget. It is important to note that the dates of these surveys of course preceded the dates of publishing the studies reports as indicated in the list of references. For example, in the latest study published in 2002, the home interview survey and the supply surveys were carried out in 2000/2001, about two years earlier than the publication date of the study final report. In the current research work it is necessary to distinguish between the two respective dates for each study as when we analyse transport evolution we should refer to the precise date of the information we possess and also when we give a reference list we must record the date of the publication. In addition, for some studies detailed data is not available. This has been considered in the progress of work and is indicated below. In between the above mentioned major studies, other transport studies were also performed but did not undertake any noticeable field surveys. They are useful but not comprehensive and are occasionally referred to.

The major urban transport studies carried out in GC that undertook demand and supply surveys, referred to above, are listed below and summarized in Table 3, (3); indicating the date of publication of the report and the date of undertaking the surveys for each study.

- SOFRETU 1971 study (15): (the study report could not be obtained): the surveys were carried out 1970/71 and only few extracts of the results are at the disposal of the Study Team.
- MIT/Cairo University 1983 study (25): the surveys were carried out in 1977 and 1978.
- JICA 1989 study (14): the survey was carried out 1987. We only possess one of the Draft Reports.
- SYSTRA/DRTPC, et al, 1999/2001 study (13, 26, 27, 28 & 29): the survey was carried out 1998.
- JICA CREATS 2002 study (10, 19 & 30): the survey was carried out 2000/2001. Because the O/D survey was completed in December 2000 and other surveys completed in early 2001, we shall consider the date as 2001.

Accordingly, GC transport supply and passenger travel demand saw five distinctive surveys and information gathering in 1971, 1978, 1987, 1998 and 2001. Those are the "governing years" referred to in Sections 2, 4, 5 and 6 of the Report.

Similar to transport studies in other cities of the world, each of the GC studies has its own features, powers and limitations according to the objective and the budget availability among other reasons of course. It is important, therefore, to note the following summary of the above mentioned studies objectives.

SOFRETU 1973 Study, (15)

The objective was to arrive at a transport projects plan for CG; mainly to set out the needed metro lines network in view of other projects for the city. The Ministry of Transport did not want to decide on the metro before a transport study is undertaken. The study came up with a recommendation of the need for three metro lines. Based on its results Metro Lines 1 and 2 were constructed and operated later in the 1980 and 1990s. The reason of the delay is discussed later. In addition the study recommended some solutions for bus transport and traffic management.

Table 3: Summary of previous major transport studies for Greater Cairo, (3)

Publication date* and Consultant	Study Client	Study Area	O/D Survey year	Survey type and sample size
1973, SOFRETU	Transport Planning Authority	GC	1971	Home interview, 10000 households
1983, DRTPC/MIT	Cairo University	GC	1978	Roadside-interview, 1978, NA
1989, JICA,	Cairo Governorate	GC	1987	Home interview, 17000 households
1999, SYSTRA/ DRTPC, et al,	National Authority for Tunnels	GC	1998	Home interview, 12500 households**
2002, JICA,	Ministry of Transport	GC and Region	2000/01⁺	Home interview, 54800 households***

* Reference details are given in the list of references.

** Survey carried out by the Transportation Programme, DRTPC, Cairo University

*** Survey carried out by the Transportation Programme, DRTPC, Cairo University, in cooperation with Ain Shams University, Transport Unit of the Faculty of Engineering

+ Surveys carried out between December 2000 and January 2001 and hence the date is considered 2001

MIT/Cairo University 1983 Study, (25):

This is a research study (not a consulting one) and academic cooperation between the two respective institutions, Cairo University (Transport Staff of Civil Engineering, Faculty of Engineering) and Massachusetts Institute of Technology (mainly the Transport Facilities Division Staff of Civil Engineering). Among the objectives was to involve the Ministry of Transport Agencies in the applied research effort demonstrating the importance of the modern civil engineering sciences of urban transport planning: undertaking specialized surveys and developing mathematical models of travel demand for use in the transport planning effort.

JICA 1989 Study, (14):

This study was undertaken at a strategic macro level to investigate possible future transport projects of all types in GC.

SYSTRA/DRTPC, et al, 2002 Study, (29):

After construction of metro Lines 1 and 2 based on the SOFRETU Study of 1973 mentioned above, the Ministry of Transport did not want to start on a third metro line before undertaking another study to update the 1973 study in view of the structural changes of city development geographical direction and to update demand forecasts for the future based on the late 1990s conditions. The objective of this new study was to arrive at a plan for future public transport in GC and then to study the feasibility of a third metro line. The study came up with a new configuration and alignment of Metro Line 3, Phases 1 and 2 of which are currently under construction as mentioned earlier. The study also recommended metro Line 4 and two LRTs, Line 5 and Line 6, for the future.

JICA CREATS 2002 Study, (10):

Based on the request of the Ministry of Transport, this study had the objective of considering not only GC but also the wider region that includes all the new cities, 6 Oct City in the west of CG and 10 Ramadan City in the north east, in addition to other semi urban and rural districts surrounding the agglomeration, some of which are densely populated. The study confirmed the need for metro Line 3 as in the above mentioned study (30), and recommended 60 projects of public transport and expressways for the future, including metro Line 4 and LRT lines as well.

Examples of the differences between the above studies: As mentioned earlier, the above studies vary according to the defined objectives, the relevant input and surveys, analysis and outcome, etc., as listed below, for example.

- Surveys type, methodology, sample size, etc.
- Level of analysis; being generic or detailed.
- Adopted methodology.
- Applied definitions of transport modes and systems. For instance, adding the shared taxi microbus to the Minibus of CTA, not counting the number of shared taxi vehicles, etc.
- Considering different trip types and different periods of travel (e.g., one study considered only peak hour trips), etc.
- Level and detail of the inventories of the supply, particularly the road and the bus systems.
- Type and technique of demand surveys.
- Sample size of the surveys.
- Levels of data aggregation, fine zones, districts or sectors and methods of aggregation.
- Travel demand modelling methods for prediction of future demand.
- The assumptions that had to be made and the reasons for such assumptions and the extent of explanation mentioned in the study reports.
- Presented results in the published reports as related to type of information and level of detail, enlargement of the surveys results and the forecasted demand, etc.
- Etc.

Examples of main adjustments of the surveys results for comparison, (3): In order to be able to reach comparable results of transport supply and demand between in the above mentioned governing years of the surveys, namely 1971, 1978, 1987, 1998 and 2001, certain adjustment factors were driven and applied based on intuitive judgement and supported by reasonable assumptions whenever needed. The experience and previous research work (3) of the Transport Engineering and Planning Expert of the present project has been sought in that respect.

- The 1978 survey results are given for the peak hour only. However, hourly fluctuation factors are given in the study report (25) for each mode for each of the surveyed hours of the day. Accordingly, those were used to estimate modal shares for the whole day.
- The 1987 survey was carried out just before opening of the first stage of metro Line 1 to service. Hence, it was not included in the resulting modal shares. Based on the operator statistics for 1987, the metro daily trips were obtained and with some assumptions it was introduced to modal shares for that year.
- The 2001 (NB: as mentioned above we assume it as 2001 because it was completed in December 2000) home interview survey covered a region larger than the GC area including the new cities and rural areas and villages. Utilizing the home interview survey original computer files, modal shares and trip purpose split were determined based on the traffic zones of GC excluding the outer zones.
- The 1998 home interview survey original computer files were manipulated to adjust for some traffic zones changes that had to be made to make the results comparable with 2001 survey.
- Etc.

For some of the surveys, it was not possible to obtain comparable results and those are mentioned in due course during the analysis. Furthermore, for some modes the trend analysis starts from the year of operation or the year of the mode being effective. These include: the metro starting in 1987, the shared taxi though began to appear for the first time in 1979, yet it only started to be importantly noticed in 1985 (so this was considered the real year of its effective operation) and the CTA minibus introduced in 1986. Those are also mentioned in the appropriate locations during the analysis given below.

The obtained percentages of the trends of trips by purpose (trip purpose share %) and by mode (modal market share %) for the governing years 1971, 1978, 1987, 1998 and 2001 were as appropriately determined for the years for which they were possible to determine (3). The obtained results are checked for logicity and how they compare with the expanded supply for the same years and looked very reasonable and logical (3). This allowed for analyses of the trend of evolution and proved very reasonable for the purpose of the currant study.

5.5 General Evolution of Transport Demand and Supply

Based on reference (3) and the above mentioned studies and surveys (10, 14, 15, 19 & 29), total daily trips were 5.6 million in 1971, rising to 10.8 million in 1987, 14.1 million in 1998 and 21.6 million in 2001. Walk trips reached 26% of total daily trips in 1971, increasing to 36% for both 1987 and 1998 and then reduced to 32% for 2001.

The latter drop is logical due to the much larger area of the 2001 survey compared to the earlier ones. According to the latest study (10), it is estimated that the number of daily motorized trips in 2022 will increase to about 25 million which is nearly an increase of 174 % on the 14.4 million motorized trips observed in 2001 by the same study.

Person mobility trend nearly doubled between 1971 and 2001 rising from 0.8 trip/person (15) to 1.64 trip/person (10) with a rate of 1.42 trip/person in 1998 (13, 26 to 29). So, it is clear that urban personal mobility is increasing by time. It should be noted, however, that the mobility of 1.64 trip/person reported from the 2001 survey is on the lower side. The study area (10) was much larger than GC area for the other two studies; including the new cities and rural centers surrounding GC as mentioned earlier.

To cope with the continuous increase in motorized trips, GC transport system has witnessed great expansion and changes in type, size and location, (3). For instance, in 1971 public transport consisted only of three modes, CTA bus, light rail tramway (tram and Heliopolis metro) and trolley bus. Currently, in 2009 public transport comprises 10 modes, namely CTA bus, CTA minibuses, GCBC bus, Air-conditioned bus (by CTA and GCBC), CTA River bus, light rail tramway (tram and Heliopolis metro), metro, private companies concession lines minibuses and the informal shared taxi and cooperative societies' minibuses. This is in addition to the yellow taxis (Taxi of the Capital) owned and operated by two private companies which did not exit before 2006.

In 1981 the trolley bus was withdrawn from service for technical and maneuverability problems. The informal shared taxis originally started to enter service gradually in 1979, and later as from 1985 they started to play a profound roll in the public transport market in GC. So, as mentioned above 1985 is considered in the present work as the date of the real start and competitiveness of shared taxi. In 1986 the CTA minibus was introduced. In 2001 the private minibus companies entered the public transport market in GC for the first time since 1960. Before 1960 all public transport buses belonged to two main private companies. The cooperative minibus informal modes were gradually introduced in the very late 1990s, particularly and mostly in Giza Governorate. In 1997 CTA started the operation of the Air-Conditioned bus for the first time in GC with the lines and fleet quadrupled in 2003.

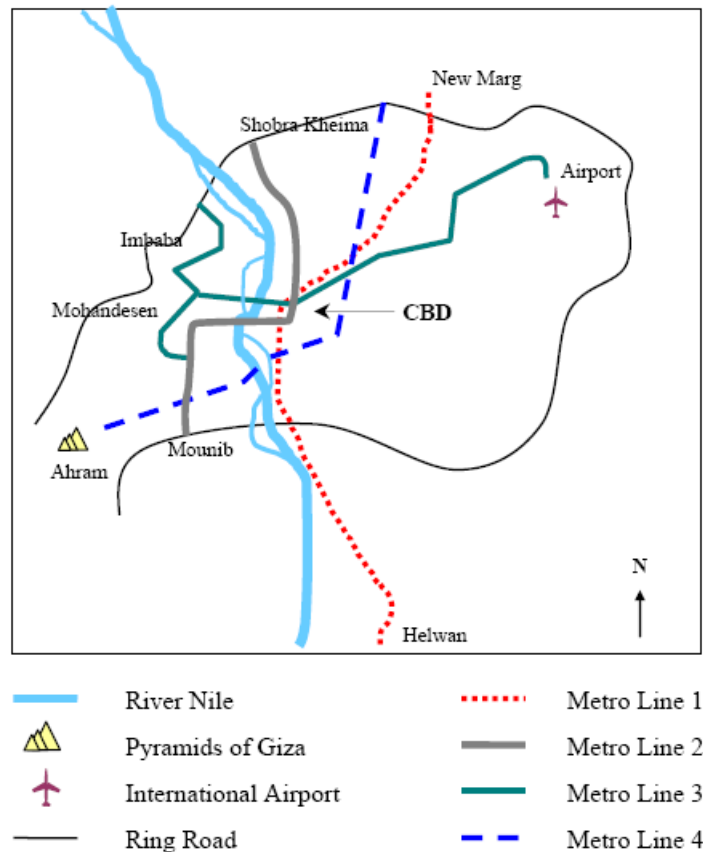
History of evolution of the GC Metro: Because of its vital importance to GC residents with its ever increasing population and travel demand and its environmentally friendly nature as well as being the first Metro Line in Africa and the Middle East and one of the very successful metros in the developing countries, a brief outline of the evolution of GC metro and its history is given below. Figure 16 also shows GC present and future metro lines.

- In 1934, the first idea of Cairo metro project was first initiated by the late Engineer Saied Abd El Wahed the Chairman of Egypt National Railways to link the two suburban (at that time) rail lines through the CBD. These are the line from Helwan in the south of Cairo to Bab El Louk in the south of the CBD and the line from Kobry El Laymoon in north of the CBD to Al Marg in the north east of Cairo.

- In 1971, the Ministry of Transport launched the first transport study which suggested three metro lines, Line 1 of which is on the same route of the 1934 suggested line.
- Due to the successive war times between World War II in the late 1930s and the October War in the early 1970s, it was not possible to start any metro project.
- On 27 September, 1987, Phase I of metro Line 1 was opened to service between Helwan Station in the south and Mubarak Station in the CBD. This is a historic day for urban transportation in Africa and the Middle East, marking the start of operation of the 1st Metro Line in the mighty content and the grand region. For details on this historic line the reader can refer to (31).
- On 12 April, 1989, Phase II of metro Line 1 was completed extending the line between Mubarak Station and Al Marg Station in the north east; thus completing Line 1 Hewlan/Al Marg.
- On 1st Oct, 1996, Phase I of metro Line 2 was opened to service between Shoubra Al Khima Station in the north and Mubarak Station in the CBD.
- On 21 September, 1997, Line 2 was extended between Mubarak Station and Sadat Station; thus completing Phase II: Shoubra Al Khima/Sadat.
- On 19 April, 1999, Line 2 was further extended between Sadat Station and Cairo University Satiation (at Tahrir Square in the CBD); thus completing Phase III Shoubra Al Khima/Cairo University. This extension under-passed the River Nile twice crossing the Island of Zamalek and entering Giza Governorate for the first time.
- On 8 October, 2000, Line 2 was extended again between Cairo University Station and Om EL Masreieen Staion; thus completing Phase IV of Line 2: Shoubra Al Khima/Om EL Masreieen.
- On 17 January, 2005, Line 2 was extended once more between Om EL Masreieen Staion and Al Monib Station near the Ring Road; thus completing Phase IV of Line 2: Shoubra Al Khima/Al Monib.
- In 2007, the construction of Phases I and II of metro Line 3 started between Al Attaba Station in the CBD and Al Ahram Station in Heliopolis.
- In December 2008 the transport planning, feasibility, design and preparation pf tender documents of Phase III of Line 3 started. The planned start of implementation is decided after the opening of Phases I and II to service. The same is for Phase I of Line 4 between Al Ahram Station near Giza Pyramids Plateau and Al Malek El Saleh Station in Cairo linking Line 1. Realizing the vital importance of the metro to a mega city like GC, the government is determined to start the above two phases of Lines 3 and 4 in parallel after opening Phases I and II of Line 3.

The period 1971 to 2001 saw opening three Nile bridges and a very large increase in the number of constructed over passes at major intersections. Furthermore, Al Azhar modern two car tunnels mentioned earlier were opened to service in 2001, in addition to a number of other smaller ones in Cairo early 2000s. Four major elevated expressways are completed; one of those, 6 October Elevated Road, was constructed in successive stages since 1969 with a total length of about 15 km. The Ring Road of some 100 km was completed in the mid 1990s and three additional elevated expressways are completed in the late 1990s to link surrounding new developments with the City. In the summer of 2008 a major tunnel was opened in Giza to solve a highly congested bottle neck. A new elevated expressway is due for completion in 2009 that shall link the Ring Road with two major districts in Giza as well.

Terminal 2 of Cairo International Airport was opened to air traffic in 1985 and Terminal 3 is opened early 2009, a very successful project and the only Airport project in the world financed by the World Bank in the period 1995 to 2005 (32). Two main reasons were given by Bank staff; the carefully performed feasibility study and the existence of excellent management in the benefiting agency, the Egyptian Holding Company of Airports and Air Navigation of Egypt; that made the Bank confident of the success of the project.



NB:

- L1 Operated 1987
- L2 Operated 1996
- L3 Phase I & II under construction (Phase I, opening 2011 and Phase II, opening 2013)
Phase III Feasibility & Tender Documents preparation (2009)
- L4 Phase I Feasibility & Tender Documents preparation (2009)

Figure 16: Greater Cairo Metro Lines Network

Six grand parking garages were built in the CBD starting in 1986 and currently another two are near completion. Furthermore, major multistory car parks are constructed successively particularly in the 1990s and onwards. Many of the existing bus terminals are expanded and others constructed on the fringes of the city. Intercity Bus Stations that were located in inner Cairo way before the 1950s were closed and removed to the fringes over the past 10 years.

For precision, the evolution of the number of cars is given for Cairo Governorate alone and not for GC, based on reference (3). Car registration in Cairo Governorate has been increasing always. Between 1976 and 2001 the number of cars rose dramatically from about 86000 cars to about 625000 cars which is a remarkable 727% increase! In 2007 the number reached about 960000 cars, which is an increase of 1116% compared to 1976, and of 154% compared to 2001. The evolution index between successive years taking 1976 as a base year is found to be 4.2 for 1986, 5.9 for 1996, 7.3 for 2001 and 11.2 for 2007. References (13, 26 to 29) give some values for GC car ownership and income, indicating that the number of cars/household in GC based on the 1998 survey of the same study was concentrated in the highest income groups, reaching 1.2 cars/household, compared to 0.03 cars/household in the lowest income group and this is quite logical.

The evolution of daily trips by trip purpose share (%) is given in Table 4 for the four survey years 1971, 1987, 1998 and 2001, because it was not possible to obtain the relevant percentages for the 1978 survey, (3). The trend of the share of work trips dropped from 26% 1971 to 21% in 1987 and 20% in each of the years 1998 and 2001. This is mainly due to the reduction of the number of working days of the week to five days in many government and private agencies and businesses from the late 1980s onwards. The trend of share of education trips over the years shows clear increase from 15% of daily trips in 1971 to 20% and 23% in 1987 and 1998, respectively, and 25% in 2001. This matches the continuous increase in the number of education institutions as a result of the government education policies in GC and also nationwide. For instance, the number of Universities in GC and region alone has increased from 4 in 1971 to 10 in 2001 and in the country from 6 to 20 over the same period (3).

Table 4: Evolution of Greater Cairo trips by trip purpose share (%) in the governing years, (3)

Trip Purpose	1971	1987	1998	2001
Work	26%	21%	20%	20%
School	14%	19%	22%	24%
Home	41%	48%	49%	49%
Other	19%	12%	9%	7%

Table 5 gives the evolution of GC daily trips by modal shares (%) for the five governing survey years for the main motorized modes; car (+ taxi), bus (+ minibus), light rail (tram + Heliopolis metro), metro and shared taxi, the following comments can be made (3). The share of car trips increased from 14% to 31% and 38% of total daily trips by all modes in 1971, 1978 and 1987, respectively. This may be attributed to the application of the economic open door policy after 1973 which allowed big increase in car imports. Then, sharp drop happened after 1987 and the percentage decreased to 20% in 1998 with a slight increase to 23 % in 2001. This may be attributed to the rationalization of car imports in the early 1980 and also to the start of operation of metro Line 1 in 1987 which attracted many of the car users to shift escaping from the obligation to drive on the congested street network. This is evident

from the ever increasing number of parked cars around metro satiations in the high income fringe districts in the south and the north. Furthermore, the introduction of the Air Conditioned bus, for the first time, attracted also many car users. For instance, between 1998 and 2001, the share of Air Conditioned bus trips out of total motorized trips rose from 0.3% to 1.0% which is a remarkable increase of 333% in view of the number of buses in service and the daily trips increased 10 fold between 1997 and 2003, (3). It would have been interesting if statistics on the past evolution of car use and not only cars and car owner ship was available. This is indeed a more meaningful feature to study, as discussed in reference (33).

It is clear from Table 5 that the trend of the evolution of bus and minibus share of daily trips by all modes is steadily decreasing all the way, (3). In 1971 this share was 70% and in 2001 it reached only 22%. In between, the share was 56%, 41% and 28% in 1978, 1987 and 1998, respectively. This decline in bus and minibus trips is still undergoing; compared to daily trips on these two CTA modes of 3 million daily trips in 2001 it is reported by CTA that for 2008 this number was reduced to 2.2 million daily trips. On the other hand, shared taxi share in daily trips increased steadily and sharply since it started to play an important roll from 1985 onwards, though it was first introduced in 1979, jumping from 6% in 1987 to 35% in 1998 and 37% in 2001. Clearly the shared taxi captured many of the bus users as, compared to bus, it provides high access to land use units and it is faster and demand responsive serving instantaneously the market needs. As mentioned earlier, for example, the shared taxi has succeeded in feeding the metro at successive stations along the two lines much more than the bus has done.

Similarly, metro share of the market of daily trips has always been on the increase since its introduction in 1987 when the share was only 6% and reached 16% in 1998 and 17% in 2001, (3). In 2001 the observed daily metro trips were 2 million trips (10) compared to a 2008 recorded value of an average of 2.35 million trips daily, with a maximum of 3 million trips as reported by the operator ECM in February 2009. This again confirms the increasing trend of the evolution of metro trips. This again capturing considerable number of trips from the bus as it did with those made by car, particularly the trips moving along the corridors served by the metro. It is obvious that the metro is faster, more comfortable, safer and more reliable.

Finally, the decrease in light rail trips over the past years is observed and is also obvious as a result of neglecting this mode and the elimination of many of the tram tracks in Cairo since the 1950s (21).

Table 5: Evaluation of modal share of motorized trip (%) in the governing years, (3)

Transport Mode	1971	1978	1987	1998	2001
Car and Taxi	14	31	38	20	23
Bus and Minibus	70	56	41	28	22
Light Rail tram	16	13	12	1	1
Metro	0	0	3	16	17
Shared Taxi	0	0	6	35	37

6. Energy/Environment

6.1 Evolution of Energy Production and Consumption in Egypt

The energy sector plays a substantial role in economic development of Egypt and fulfils domestic energy demand on petroleum products (gasoline, kerosene, gasoil, fuel oils, and lubricants), natural gas and electricity. The main energy sources of Egypt are petroleum (oil), natural gas, coal and hydro-power, in addition to good potential in renewable energy resources that have been under consideration since the 1980s but production in commercial scale started in the late 1990s. In 2005 the production from renewable energy sources represented only 0.18% of the total energy production (34). It is hoped that this shall increase in the future.

During the period 1996 to 2005 energy consumption increased from 25.64 Mtoe to 38.65 Mtoe with an average growth rate of 4.2%. Concerning the analysis of sectors shares during the same period 1996 to 2005 (34), the transport sector share remained unchanged at about 30% of the total consumption but had a high annual growth rate of 5.1%, reflecting the corresponding increase of transportation demand in the country. Whereas, the industry sector share in energy consumption decreased from 50% to 40.7% over the above mentioned period. However, the absolute consumption of the industry sector (in Mtoe) increased by only 2.1%; which is half the annual growth rate of the total energy consumption. The residential and commercial sector shares increased from 17.82% to 22.02%, with an average annual growth rate of 6.5%. Although government buildings and utilities, mainly water, drainage, and street lighting, showed the highest annual growth rate of 7.9% during the same period 1996 to 2005, they have a modest share in total energy consumption together with agriculture production.

6.2 Egypt Greenhouse Gas Emissions

Based on the 1995 IPCC (Intergovernmental Panel for Climate Change) guidelines and default emission factors, the first GHG inventory of Egypt was developed for 1991, (35). It was part of the preparation of the Initial National Communication on Climate Change that was submitted to United Nations Framework Convention on Climate Change (UNFCCC) in 1999. The inventory was estimated for the main three greenhouse gas (GHG) emissions, namely CO₂, CH₄ and N₂O. In Egypt CO₂ represents about 72% of the total GHG emissions. The second important GHG is CH₄, which recorded 19% of the total GHG emissions and lastly N₂O with only a 9% share.

In 1991, the total net GHG emissions were about 117000 Gg (thousand tons) of CO₂ equivalents while the total GHG sinks in the land use and forestry sector recorded 9900 Gg of CO₂ equivalent. With 92% dependence on fossil fuels, the energy sector represents the major source of GHG emissions, contributing about 71% of the national total (36).

GHG emitted from the energy sector is mainly CO₂ resulting from the consumption of fossil fuels for energy purposes in different sectors which increased from 83070 Gg of CO₂ equivalents in 1996, to 137110 Gg of CO₂ equivalents by 2005, with an annual average growth rate of 5.7%.

During 2005, the contribution of the main sectors in GHG emissions was the electrical power production sector share of 35.35%, followed by the transport sector with the share of 26%, the industry with 20.45% and the residential and commercial sector with 10.42%. Egypt national strategy study on the clean development mechanism in 2003, (37), estimated a GHG emissions annual growth rate of 4.9% from energy related activities. This would lead to an estimated contribution from energy in total GHG emissions in Egypt by 392000 Gg CO₂ equivalents by the year 2022, (37).

Table 6 gives energy indicators and CO₂ emissions of Egypt compared with selected countries in 2003. It is clear from this Table that the net energy supply of Egypt represents only 1% of total world energy supply while GHG emissions amount to 0.5% of the world total. These are very small when compared to USA and other main industrialized countries as Germany and France. The CO₂ emissions per capita are also low when compared to other countries. However, the per capita energy supply reflects the degree of industrial development except for some countries such as Saudi Arabia where considerable percentage of energy is used in water desalination.

Table 6: Energy indicators for Egypt and different countries in 2003, (based on 37)

Count.	Pop. (m)	Total Energy Supply					CO ₂ Emission		
		Prod. (Mtoe)	Import (Mtoe)	Net (Mtoe)	% World	Net toe / Cap	Mt	% World	Ton / Cap.
US	300	1654	730	2384	36.5	7.9	5697	20.3	19
Germ.	82	137	216	353	5.4	4.3	823	2.9	10
India	1110	436	135	571	8.7	0.5	1250	4.5	1.1
Brazil	189	261	20	281	4.3	1.5	332	1.2	1.8
Egypt	74	78	- 14	64	1	0.9	153	0.5	2.1
SArab.	24	571	- 422	149	2.3	6.2	340	1.2	14.2
France	63	137	140	277	4.2	4.4	377	1.3	6
Turk.	73	26	69	95	1.5	1.3	240	0.9	3.3

CO₂ emissions from fuel consumption only

Emissions are calculated using the IEAs energy balances and the revised 1996 IPCC Guidelines.

6.3 Air Pollution in GC

Egypt witnessed rapid development in industrialization and urbanization; a byproduct of which is the generation of large amounts of air pollutants and a decrease of air quality. This is particularly evident in GC and Alexandria, where more than 80 % of industrial activities take place mainly around their peripheries. Air pollution arises from natural and anthropogenic sources. The topography of the GC area, its proximity to the desert and meteorological conditions with low precipitation rates, make it particularly susceptible to natural air pollution, especially from airborne dust.

The anthropogenic sources of air pollution include industrial facilities, thermal power stations, illegal open burning of municipal solid waste and other hazardous waste, in addition to transport sources from vehicular traffic exhaust.

Among the most common air pollutants in GC are sulfur dioxide (SO₂), suspended particulate matter (SPM) and Lead (Pb). The latter mostly comes from industry and not from vehicle traffic as leaded gasoline was abandoned in 1998, as mentioned later. Other pollutants such as CO, NO_x and hydrocarbons are produced mainly from idling vehicles in the streets of GC.

The Environmental Information and Monitoring Programme (EIMP) was established in 1997, under the Environmental Quality Sector of Egypt Environmental Affairs Agency (EEAA), in order to give a view of the present environment and to undertake the monitoring of ambient air by establishing a modern national air quality network. Data are collected using automatic on line monitors and a variety of sampling equipment. A total of 42 sites covering the country were selected to locate the stations; 14 of which are in GC. The installation of the stations was completed in 1999. The following reports are being produced regularly:

- Daily reports on air quality in GC.
- Monthly reports on air quality in Egypt.
- Annual report on air quality in Egypt.

The reported data show that in 2001 the SO₂ concentration levels in GC exceeded the Egyptian Air Quality Limit of 60 µg/m³, in some districts. The value of SO₂ concentration ranged between 12 µg/m³ and 65 µg/m³ in residential districts, with the maximum value observed in Al_Qlally District. While in some industrial areas as Shoubra Al Khima, SO₂ concentration reached 66 µg/m³, (38). The concentration of particulate matter, PM₁₀, in the industrial districts of Shoubra Al Kheima and Abou Zaabal reached an annual average of more than 250 µg/m³, which is about 4 times the air quality limit value for Egypt of 70 µg/m³, (38). These high concentrations are observed near the areas of the cement and brick industries as well as along congested urban streets. In the residential areas of GC, a maximum of 177 µg/m³ was observed in Al Abbasia and a minimum of 58 µg/m³ in Al Maadi, (38).

The concentration of other pollutants such as carbon monoxide, oxides of nitrogen and hydrocarbon are growing along congested streets of GC where vehicles are idling or moving at very low speeds. For instance, high concentrations of CO of 8.23 mg/m³ was observed in the residential areas such as Foum El Khalig due to traffic congestion and a maximum annual average concentration of NO₂ of 76 µg/m³ and a minimum of 30 µg/m³ in Al Tebbin, (38). The significant source of atmospheric lead (Pd) in Egypt was the use of leaded gasoline in motor vehicles before the turn of the century. In 1998 Egypt successfully started phasing out the use of leaded gasoline. Consequently, lead concentration in GC residential areas decreased considerably ever since. Currently as mentioned earlier, the major lead emissions come from industrial sources, particularly the secondary lead smelters handling car batteries, most of which are located in the GC.

6.4 GC Road Fleet Analyses for the Governing Years

The road fleet in GC, likewise many other mega cities in the world, consists of vehicles of various makes, models, sizes and age. The main components are small cars, trucks, busses and motor cycles.

Table 7 based on (39), gives the evolution of the number of vehicles in GC by major types in the governing years of the current study. It is clear that vehicles are increasing at high rates over the governing years during the more recent years 1998 to 2001 as the average annual rate of increase is 4.5%. On the other hand, the available main street network in GC is not increasing with the same rates either in length, width or capacity, resulting in a continuous decrease in average travel speed (10).

Table 7: Evolution of the number of vehicles in Greater Cairo in the governing years, (based on 39)

Year		Cars	B + MB	ST*	Tr	MC	Total
1971	No.	80755	2969	NA	9682	10687	104095
	%	78	3	--	9	10	100
1978	No.	167707	6062	NA	23179	32453	229401
	%	73	3	--	10	14	100
1987	No.	491923	12807	40000	82500	99653	726883
	%	68	2	6	11	13	100
1998	No.	902505	20276	50025	141857	166817	1281480
	%	70	2	4	11	13	100
2001	No.	1039617	27428	51005	162361	185158	1454699
	%	70	2	4	11	13	100
Average annual rate of increase 1998/2001 (%)		4.7 %	11.8 %	0.7 %	4.8 %	3.7 %	4.5 %

Cars = (Private cars + Taxi + other small cars), B = Bus, MB = Mini Bus, Tr = Trucks, ST = Shared Taxi, MC = Motor Cycle, NE = Mode did not exit in the indicated year.

* Estimated

The evolution of the number of each type of the small cars in GC over the governing years is given in Table 8. The small cars include private cars, taxis and others (e.g., government, commercial, and other own account cars) and constitute the main component of GC road based fleet. Their percentage as shown in Table 7 ranged from 68% to 78% over the governing years. The private cars are always between 79% and 84% of the total number of small cars over the governing years. It is interesting to observe that the number of the taxis remained constant in 1987 and 1998. This may be due to the local legislations that prohibited registration of new taxis in Cairo during this period. This, however, affected the age distribution of taxis. At present small cars especially taxis include a relatively high percentage of the old small cars. Private cars of more than 25 years old are more than 17% of all private cars and 32% of the taxis are more than 25 years old, (39). These old taxi are mostly fiat vehicles (more than 60%) that possess high fuel consumption and high pollutants emissions.

Small trucks are about 17% in the 1970s and they started to increase rapidly after that year reaching about 60% in the 1980s and then they remained unchanged. This is a result of the application of the open door economic policy in the late 1970s when most commercial businesses and small contracting companies started to use small and medium trucks heavily extending to the 1980s as well. During the period of the 1980s most of small trucks were fueled with gasoline, but after the increase of the price of oil they were converted into diesel. At present only less than 15% of small trucks are still powered with gasoline engines (39).

Table 8: Evolution of the number of different types of small cars in Greater Cairo in the governing years, (based on 39)

Year		P Car	Taxi	Other	Total
1971	No.	68149	10400	2206	80755
	%	84	13	3	100
1978	No.	139945	22570	5192	167707
	%	84	13	3	100
1987	No.	385609	66314	40000	491923
	%	79	13	8	100
1998	No.	754036	66314	82155	902505
	%	84	7	9	100
2001	No.	876378	78483	84756	1039617
	%	84	8	8	100

The number of buses and minibuses constitutes a small percentage of GC road based fleet. They include as given in Table 9 public buses and minibuses as well private buses and minibuses (school, tourism, etc.). CTA and other public busses and minibuses are heavily used in GC but constitute a small percentage of the total number of buses, 53% in 1971 and only 17% in 2001. On the other hand, the numbers of other busses such as private, school and tourism busses are rapidly increasing as most companies and schools prefer to use their "own account" bus fleets. This is in addition to the continuous increase in schools, tourism agencies and other private businesses that are taking place over the years due to the corresponding increase in private education, cultural, commercial and economic activities and the market oriented policies of the government adopted from the 1990s onwards. Other busses are registered as public bus and these belong to government and public business sector.

6.5 Evolution of Fuel Consumption and Emissions from Road Transport in Greater Cairo for the Governing Years

Road based transport in GC consumes petroleum products, gasoline and gasoil, and more recently compressed natural gas (CNG), in addition to lubricating oils and greases, while Cairo Metro and the light rail (Tram and Heliopolis metro) obviously are electric power driven. To correctly calculate GHG and pollutants emissions, the fuel consumption has to be allocated to different modes of transport. Data collected from fuel producers, fuel distribution companies and main consumers show some inconsistencies and only give the fuel consumption for the whole country and not for individual cities. In the present study, fuel consumption and emission factors are chosen from different references according to vehicle type, technology, model and speed, in order to calculate fuel consumption and emissions (40, 41, & 42). After applying reasonable assumptions and adjustments concerning average speed and annual travel distance for each vehicle type, the reached results are presented in the following sections.

Table 9: Evolution of the number of buses and minibuses in Greater Cairo in the governing years, (based on 14, 20, 25 & 39)

Year		CTA Bus	CTA Minibus	Other Public Bus	Private Bus	Total
1971	No	1415	NE	1516	38	2969
	%	48	0	51	1	100
1978	No	1439	NE	1081	3542	6062
	%	24	0	18	58	100
1987	No	2000	498	1690	8619	12807
	%	16	4	13	67	100
1998	No	2561	750	2901	14064	20276
	%	13	4	14	69	100
2001	No	2690	820	2540	21378	27428
	%	10	3	9	78	100

NE = not existing

6.5.1 Evolution of transport fuel consumption and fuel cost

The evolution of fuel consumption in GC by fuel type is given in Table 10 for the governing years of the present study. It is clear that fuel consumption was steadily increasing at high rate of 6.8% during the period 1987 to 2001, due to the increase of the number of vehicles, vehicular traffic and the corresponding decrease of the average speed. Table 10 also gives the energy consumption of Cairo metro expressed as Ktoe, for comparison purposes, where the equivalent "toe" of GC metro energy consumption is calculated considering local electricity mix as well as generation and transmission efficiencies of electricity. The Table indicates that the energy consumption of the metro is > 5% of the total energy consumption in 2001, which is very low compared to its modal share in transport of 17% of total motorized daily trips in that year as given in Section 5. Table 10 also gives the average annual increase rate of the total energy consumption in road-based transport in GC is about 7% during the period 1998 to 2001 which is higher than the rate of increase of the total number of vehicles of 4.5% as given in Table 7 for the same period. This could be attributed to the decrease of the average speed that strongly affects specific fuel consumption (liters/km). Table 10 also depicts the high rate of gasoline consumption that could be a problem taken into account that the production from oil and oil products are decreasing. Expansion of metro network could be part of the solution.

Considering the different transport modes, Table 11 gives the evolution of fuel consumption by road transport vehicles in GC as determined by the current study Energy/Environment Expert.

It indicates that most of the transportation fuel is consumed by small cars, mainly private cars and taxis, 51% of the total transport energy in 2001 for example, and trucks consuming 27% of the total transport energy in the same year.

Table 10: Evolution of Greater Cairo transport energy consumption by fuel type in the governing years

Year	Gasoline (kt)	Solar (kt)	RB (Ktoe)	M (Ktoe)	RB + M (Ktoe)
1971	100	107	224	NA	224
1978	196	168	395	NA	395
1987	647	467	1209	4	1213
1998	939	863	1951	88	2039
2001	1204	982	2368	99	2468
Average annual increase rate during 1998/2001 % *	9.4	4.6	7.1	4.2	7.0

RB = Road-Based Modes, M = Metro

* Only given for 1998 and 2001 to base on the calculations after the both of the Metro lines 1 and 2 are operated.

Table 11: Evolution of fuel consumption (Ktoe) by transport modes in Greater Cairo in the governing years

Year	Mode*	S Car	B+MB	ST	Tr	M	Total
1978	No.	188	82	NE	97	NE	367
	%	51	23	0	26	0	100
1987	No.	556	166	117	355	4	1198
	%	46	13.7	10	30	0.3	100
1998	No.	913	269	175	577	88	2022
	%	45	13	9	29	4	100
2001	No.	1203	305	182	656	99	2445
	%	49	12	8	27	4	100

* S Car = Small Car, B+MB = Bus and Minibus, ST= Shared Taxi, Tr = Trucks, M = Metro

It is interesting to note that both of the above mentioned modes have the highest fuel consumption per unit movement of pax.km or ton.km, respectively, (36). The share of buses and minibuses in the total energy consumption is decreasing due to the decline of their modal share as discussed in Section 5.

Table 12 gives the evolution of the cost of fuel of transport modes in GC for the governing years of the present study based on (43), where it is clear that the cost is continuously increasing irrespective of the fluctuation of international oil prices. The difference between local and international prices is accordingly fluctuating and sometimes the international oil prices are less than the local price. It happens that for the governing years, the crude oil prices dropped to very low values in 1998 and in turn the international prices of petroleum products dropped in that year.

During the period of high crude oil prices the international price of fuels, especially gasoil, could be several times more than the local price. The government keeps the local fuel price low through subsidies. In 2004 Egypt ranked second after Venezuela when considering fuel subsidy as 14 % of total state revenues were spent on subsidizing fuel. In the same year other countries such as USA and France earned about 12% of its total state revenues from fuel taxation and South Korea receives 33 % of its total state revenues from fuel taxation (43). Rationalization of fuel consumption and using transport modes of low specific fuel consumption such as the metro can effectively reduce the fuel subsidy and expected imported fuel bill in the near future (see Section 7).

Table 12: Evolution of the estimated cost of fuel consumption in Greater Cairo in the governing years (based on 43)

Year	Local Price (\$ M)	International Price (\$ M)	Int. Oil Price (\$/Barrel)
1971*	21.7	24.5	6
1978*	56.2	73.8	14.35
1987	279.7	287.5	17.66
1998	485.0	388.6	11.84
2001	560.8	737.3	21.82

* Metro not existing

6.5.2 Evolution of greenhouse gas emissions from road-based transport

The greenhouse gases emitted from road transport in GC are CO₂, CH₄ and N₂O. While CO₂ emissions are directly related to fuel consumption and type of fuel with minor effect of vehicle characteristics, CH₄ and N₂O are strongly affected by vehicle characteristics. Generally speaking, most CH₄ is emitted from gasoline and CNG powered vehicles as well as the two stroke motorcycle. However, the metro contribution to gas emissions comes from the fuel burned in power stations. The equivalent GHG emissions for the metro are calculated from the equivalent fuel consumption as discussed above in Section 6.5.1 taking into account that the electrical power stations fuel in Egypt is mostly natural gas.

Table 13 gives the evolution of GHG emitted from GC vehicular transport fleet. The increase of CO₂ is similar to that of fuel consumption given in Table 9. The CO₂ equivalent of GHG emitted from GC transport in 2001 is about 7.2 million tons which represents more than 26% of that emitted from the transport sector in Egypt. The increase in the percentage of gasoline vehicles are converted to run with CNG can reduce CO₂ emissions as the emission factor of CNG is about 2.6 kg CO₂ per kg fuel compared to about 3.1 kg CO₂ per kg fuel for gasoline and gasoil. Here again GHG emissions due to use of the metro is less than 3% of the total emission from GC transport sector.

Table 13: Evolution of greenhouse gas emission from transport in Greater Cairo in the governing years

Year	RB			M CO ₂ (k t)	Total CO ₂ (equivalent k t)	% of total Egypt transport GHG
	CO ₂ (k t)	N ₂ O (k t)	CH ₄ (k t)			
1971	582	0.02	0.12	NE	617	NA
1978	1018	0.04	0.25	NE	1093	NA
1987	3304	0.15	0.88	8 (0.2%)	3576	NA
1998	5396	0.19	1.33	179 (3%)	5972	22
2001	6537	0.21	1.47	212 (3%)	7189	26
AV. Annual growth rate 1998-2001 % *	7	3.5	3.5	6	7	NA

RB = Road Based Modes, M = Metro
NE= Not Existing, NA= Not Available

* Only given for 1998 and 2001 to base on the calculations after the both of the Metro lines 1 and 2 are operated.

In addition to GHG emissions, transport in GC is responsible of air pollution. The main pollutants emitted from vehicles are carbon monoxide (CO), oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in addition to smoke and particulate matter. Table 14 demonstrates the vast increasing emission rates of the main air pollutants caused by increasing number of vehicles and longer idling and low speed driving times. During the period 1998 to 2001 CO emissions increased at an average annual rate of 5.2%, NO_x at 4.1 % and VOC at 4.4%. CO and VOC are expected to increase at higher rates in the coming years due decreased speeds (10) and longer idling times. The larger contribution will be due to small gasoline cars that operate with rich fuel air mixture at idling and very low speeds. Operating on rich fuel air mixture means incomplete combustion and emission of larger amount of CO and VOC. Converting gasoline engines to run with natural gas will reduce CO emissions and increase VOC emissions. However, VOC emitted from natural gas vehicles is mostly methane which is a less effective pollutant when compared to VOC emitted from gasoline engines.

Table 14: Pollutants emission from transport in Greater Cairo in the governing years

Year	NO _x (k t)	CO (k t)	VOC (k t)
1971	7	39	5
1978	11	57	9
1987	31	182	27
1998	49	217	38
2001	55	251	43
Av. Annual increase rate during 1998/2001 %	4.1	5.2	4.4

7. Evolution and Current Impact of the Metro on Fuel Consumption and Cost and GHG Emissions

As any other electric mass transit systems, GC metro as an environmentally friendly mode of transport has sound impact on reducing fuel consumption and improving the environment. Table 15 gives the evolution of estimated impact of GC metro in terms of the additional amount of fuel consumption and extra GHG emissions if the metro did not exist in 1987, 1998 and 2001. Or in other words, if its passengers used road-based transport modes: private car, taxi, public transport bus and minibus and the informal shared taxi, instead; assuming the same modal shares given in Table 5. It is clear from Table 15 that when metro trips increase, its impact consequently increases too. For example, between 1987 and 2001 daily trips increased from 0.08 m pax/day to 2.0 m pax/day, while the saved fuel is estimated to would have been increased from only 6 ktoe to 150 ktoe which is a huge increase of 2500%. As for the estimated saving in CO₂ emissions, the extent of increase is even more and estimated to would have reached 2622% raising from 18 kt to 472 kt over the same period between 1987 and 2001, respectively. Globally, in 2001 the saved fuel due to the use of metro is estimated to reach 6.1% of the total fuel consumption of transport in GC, while the saved CO₂ is estimated to reach 6.6% of the total CO₂ emissions form transport in GC as well. Meanwhile, the cost of the above amount of fuel saving due to the existence of the metro in 2001 is estimated to reach \$ 51.8 million.

As for air pollution gas emissions, though they could not be estimated in the current research due to lack of needed information for accurate estimates, they are, however, expected to be much lower with the metro than without metro. This is due to the fact that the exhaust gases of the power generation stations that generate metro electricity is much cleaner compared to the exhaust gases of motor vehicles as the latter consumes natural gas.

Table 15: Evolution of estimated impact of the metro on transport fuel consumption and fuel prices and GHG emissions in Greater Cairo.

Year	Metro trips*		Fuel Consumption (ktoe)		Fuel saved (ktoe)	CO ₂ emissions (kt)		CO ₂ saved (kt)	Value of saved fuel (\$ m)
	No. (m)	Share (%)	With Metro	Without Metro		With Metro	Without Metro		
1987	0.08	3	1213	1219	6	3576	3594	18	1.5
1998	1.80	16	2039	2142	103	5972	6298	326	23.1
2001	2.00	17	2468	2618	150	7189	7661	472	51.8

* See Table 5

In addition, for 2007, it is estimated that fuel savings due to metro use would be 194 ktoe, which is 127% increase over 2001; and CO₂ savings would reach 608 kt, rising by 129% compared to 2001. Since international oil price in 2001 was \$21.82/barrel, while in 2007 it was at average price of \$70/barrel, accordingly the price of the saved fuel in 2007 is \$64 million at local prices and \$153 million at international prices.

It should be noted that in reality the above estimates are at a low side, as values of the savings in fuel consumption (ktoe), CO₂ emissions (kt) and cost of fuel saving (\$ million) are believed to be much higher than those previously indicated if we consider the increased delay and the reduction of average traffic speed on the road network resulting from the huge numbers of vehicles (expressed better in "passenger car units", pcu's) that replaces metro trips had it not been existing in GC. To illustrate, we take the case of 2008, and examine the number of vehicles that are estimated to run on GC street network particularly on the metro Line 1 and Line 2 corridors had the two lines not been in operation. Based on ECM operation statistics for 2008, the average daily trips on the two lines of the metro reached 2.35 m trip/day and the recorded maximum is 3.00 m trip/day. If we assume that the two lines do not exist in 2008, then the passengers would have to use road-based motorized modes instead; because their travel distances are too long to be done on foot. These replacement modes are mainly the private car, taxi, public transport bus and minibus and the informal shared taxi as mentioned above. Resolving to reasonable assumptions (e.g., modal shares of 2001, numbers of trips per mode, average trip length, etc.) the number of daily vehicular trips if the metro did not exist is estimated at 168000 vehicles or 170000 pcu's to be running daily on the corridors of the two metro lines. Furthermore, considering the maximum record of daily trips of 3.00 m trip/day the corridors of the two metro lines are estimated to carry additional traffic of 216000 vehicles or 218000 pcu's.

Currently, in many instants of the day, the two corridors on which metro lines 1 and 2, which are more than 80 km length are very congested even with the metro in operation, with low level of service and traffic volumes approaching capacity. The two lines also pass, under the ground, through the CBD and through high density areas north and west of the CBD and Line 2 crosses the River Nile twice. Alternatively the equivalent added vehicular traffic if the metro do not exist is obliged to do the same but using the "at grade" street network and the bridges. Consequently, the added numbers of vehicles (pcu's) will make the situation even worse; not only on the CBD but also on the street networks around the two corridors and in the districts that the two metro lines cross and on and around the entrances and exits of the bridges. The result is: more congestion, increased delay and bottle necks, increased pedestrian/vehicle conflicts, etc. and eventually reduced operating speed. Therefore, fuel consumption, CO₂ emissions and air pollution gases are expected to increase much more than the above estimates. Furthermore, other serious side effects are certainly expected to take place if the metro do not exist. These include, in addition to congestion and reduced speed, increased unproductive driving time for car drivers searching for parking places and increased accident potential, noise levels and distorted city image.

8. Links between Land Use, Transport and Energy/Environment; Transferable Lessons from Greater Cairo

The links between land use activities and transport are obvious as land use generate transport demand that should be absorbed by transport supply of infrastructure and fleet. In the same time it is also obvious that transportation activities lead to energy consumption and environmental impacts.



So, "transport" lies between "land use" from one hand and "energy/environment" from the other. In this section we focus on related transferable lessons from GC experience. Over the years since the 1970s, and even earlier, many "land use" and "transport" related elements contributed to increased congestion, traffic delay and hence, to energy consumption and to undesirable environmental impacts in GC. In the same time, many policies and projects related to "land use" development and "transport" had been implemented in GC since the 1970s; well before the environment was an issue of concern and luckily enough had positive impact on energy savings and brought about environmental improvements. This is irrespective of the fact that some of those policies and projects were not initially introduced with those objectives in mind.

The section starts by explaining some of the main elements related to both "land use" and "transport" that contributed to increased energy consumption and environmental degradation over the past four decades. It then, discusses, briefly but pointedly, previous and current policies and projects of "land use", "transport" and "energy/environment" that have been contributing at various levels of success to the reduction of fuel consumption from transport sources and the related improvement in air quality and greenhouse gas emissions in GC over the past 40 years. These are hoped to be useful transferable lessons to sister cities in the developing countries and the Mediterranean basin; avoiding the elements casing energy consumption and emissions and borrowing the successful mitigation policies and projects.

NB: It should be noted that some of the elements and policies below are explained in the previous sections of the present report and, hence, shall only be listed. Only those that are not mentioned earlier are discussed or explained below.

8.1 Evolution of Main Elements Contributing to Energy Consumption and Environmental Degradation from Transportation

8.1.1 Land use related elements

Activity Concentration:

- Industrial Estates and CBD activates.
- Universities.
- Whole sales markets.

In 1960s, GC was affected by the general status in Egypt; a decade after the 1952 revolution, facing political, social and development challenges accompanied with economic problems. As a result, the general urban policy was to concentrate on Cairo and urban Giza, GC was first named in the very late 1960s, and to place the majority of economic activities, services and other investments in the capital of the state. This also included the, then, new industrialization policy that led to opening new industries in the south and north districts, Helwan and Shoubra Al Khima, respectively. Furthermore, Cairo CBD saw further growth by the increase in the number of shopping units, business, restaurants, hotels and banks in addition to the already existing government agencies. The giant government office block "Al Mogamaa" was established in Tahrir Square in the early 1950s attracting not only civil servants but also many of the general public that need to fulfill services offered by those government agencies.

The concentration of education activities was also witnessed as in addition to Cairo University located in Giza, another two main government Universities are located in Al Abbaseya and Madinat Nasr, namely Ain Shams and Al Azhar Universities, respectively. The wholesale Fruits & Vegetables Market was located in Rod El Farag, nearly one km from the CBD. Furthermore, since the 1960s, GC witnessed high internal migration from rural Egypt. Those migrants were seeking better job opportunities and services as mentioned earlier.

Unbalanced distribution of Home and Work locations:

- Low income housing away from job opportunities.
- High income housing away from business opportunities.

As a result of the 1960s concentration of activities in scattered locations, GC turned out to be fully saturated. The hard economic status, contributed to neglecting the housing market. There were very limited housing projects compared to increased numbers of people. So, informal housing started to emerge and many workers and employees were living far from their work locations, especially those of low income groups. Also, medium and high income families started moving to live in new expansions of Cairo and Giza such as Al Mohanedesseeen, Al Sahahfiyeen, Al Ahram and Madinat Nasr, which are mostly far from their work places in the older districts.

Concentrated Workshops Locations in the Inner Areas:

- Workshops of car repair and metal works remain in inner areas.
- Workshops for handicrafts remain in Old Cairo.

Also in the 1960s, the workshops of car repairs, metal works, wood works and others remained in central locations with the emergence of many new ones taking place as well. Districts like Abdeen, Misr Al Kadeema, Boulak, and others, had been accommodating many existing and new workshops and small factories. For the handicrafts of brass, silver, carpets and others products, they remained and flourished intensively in Mosky, Al Azhar and Al Gamalyia districts, for example. In most of those locations many of these activities were harmful to the urban environment and the local community because of noise, pollution, over crowding of the streets leading to unhealthy and uncomfortable livelihood and inconvenience to residents and visitors alike.

Adaptive reuse of urban activities:

In the 1980s and in the absence of efficient monitoring of building regulations from the local authorities many developers and businesses resolved to "adaptive reuse of urban activities", (44). Examples include villas converted into banks, private schools, private hospitals, travel agents, small business offices, etc. Other examples include the conversion of ground floor flats and parking garages in residential buildings into boutiques, restaurants, cafes and fast food services, etc. The districts that saw those changes include, for example, AL Mohandesseeen, Al Zamalek, Misr Al Gadida, Al Dokki, Al Ahram and Faisal. Some of the above changes were closely located forming "activity centers". This resulted in traffic congestion and increased parking problems.

8.1.2 Transport related elements

The main transport related elements which have been contributing to increased energy consumption in GC since the 1960s are not different from those experienced in other mega cities; particularly those of developing countries. In addition to the congested street network and the difficulties to increase capacity due to lack of space and/or the high cost required for street widening, there are the problems of the vehicular fleet age and the lack of appropriate car maintenance and engine tuning. The heavy through truck traffic carrying freight between the Delta and Upper Egypt in both directions had been obliged to cross the city, exerting heavy burden on the GC street network. However, this was relieved after the opening of the Ring Road in the mid 1990s as explained later. As far as public transport is concerned, over the periods when foreign exchange was not easily obtainable during the past four decades, particularly in the 1970s and early 1980s shortage of spare parts affected bus maintenance and engine tuning which in turn contributed to increased energy consumption. The lack of bus priority measures within the traffic stream also lead to decrease in bus commercial speeds and hence rider-ship. The continuous growth of informal 11 seats shared taxi minibuses, from the mid 1980s and beyond and with the low capacity of these vehicles and the dependence of many travelers in GC on them, made their contribution to street congestion and energy consumption profound.

The difficulty to promote the use of the bicycle is yet another reason of increased motorized trips. Reasons include the lack and difficulty to provide ample and safe cycling routes because of the narrow streets, the long travel distances in GC and to some extent to the fact that the bicycle is socially unacceptable to some traveler groups in the city. Finally, the non-existence of proper traffic management schemes and measures is unfortunately practiced in GC and accordingly contributes to the increased traffic delay on the street network. The lack of institutionalizing the profession of "Transport and Traffic Engineering and Planning", although the majority of the Universities in Egypt include undergraduate and Post Graduate programmes within Civil Engineering for this specialty, contributes a lot. A pioneer study (45) was undertaken on this issue giving drawing lessons for other countries, analyzing the problem and giving pragmatic detailed framework to start up this institutionalization in large cities, like Cairo and Alexandria, and in middle and small size cities as well.

8.2 Evolution of Main Mitigation Policies and Projects for Reducing Energy Consumption and Environmental Degradation from Transportation

8.2.1 Land use mitigation policies and projects

A) Long term policies:

- The New Cities around GC (see Section 4.3.2).
- Control of informal housing (see Section 4.3.1).

B) Medium Term Policies:

Decentralization of main activities (see Section 4.2.4)

Relocation of major activity units out of GC core

- Relocation of the wholesales Fruits & Vegetables Market from Rod Al Farag at the

fringes of the CBD with an area of 7 Hect. (70000 sq. ms) to Al Oboor New Market Place of an area of 110 Hect. (1.1 million sq. ms) in the early 1990s. The traditional wholesales Fish Market was also relocated to the same Market Place after removing from Ghamra; a very high density area the north of the CBD.

- Relocation of industrial workshops from central Cairo to outer areas at Madinat Al Herafieen on Cairo Ismlia Desert Road to magnet some of industrial workshops from various locations in GC and the transfer of a number of lead smelters from Shoubra Al Khima to the new industrial zone in Madinat Abu Zaabal to the north of GC.
- Relocation of industrial workshops from central Giza to outer areas in a future project at Al Herafieen City on km 38.5 of Cairo-Fayoum Regional Road with an area of 50 Hect. to magnet some of industrial workshops from various locations in GC.
- Relocation of workshops zone in Misr Al Kadeema close to the CBD to Al Foukhar Village, which took place in the 1990s with mixed success as some workshops moved and others are still resisting.
- Relocation of the American University moving from the heart of the CBD to New Cairo occupying an area of 110 Hect. (1.1 million sq. ms) and the British International School from Al Zamalek at the fringe of the CBD in three branches, in New Cairo, Katameya and Al Sheikh Zayed.
- The future project of the relocation of Imbaba Airport of 87 Hect. (870000 sq. ms) to a new location near 6 Oct City in the 2000s; turning the original land to a properly planned area with a number of new services including entertainment, education and cultural units as well as green area and some new housing units.

C) Short Term Policies:

- Control of adaptive reuse of activity units, which started since the 1990s with pronounced success.
- Introducing new green areas within the GC inner boundaries as the International Garden in Madinat Nasr, Arab El Mohamaddy Park in Ghamara and Al Azhar Park near Al Azhar District, for example.
- New building regulations to organize more efficiently the form and the use of new buildings including, among others of course, the necessitate provision of parking space in the new housing units. The success is varied particularly in the districts of GC compared to those in the New Cities.
- In connection with the above, is enhancing the capabilities of the local authorities to improve monitoring of the regulation in the urban fabric of GC districts.
- Stricter care for agriculture land around GC with a new Law endorsed late 1990s legalizing the removal of any expansions on these lands.

8.2.2 Main transport mitigation policies and projects

Over the years many transport policies and projects were implemented in GC since the 1970s well before the urban environment and energy were issues of concern, but, however, had positive impact on energy savings and brought about some environmental improvements irrespective of the fact that some were not initially introduced with those objectives in mind. Those are listed below:

- Between the 1970s and 2000s: new bridges over the Nile and many metallic overpasses were constructed at locations of congested street intersections and squares and those in addition to some underpasses (short tunnels) at a number of

major squares helped so much in solving the problems of congestion on the street network.

- Late 1980s and progressing: new car assembly plants which though contributed to increased number of cars, yet it in the same time introduced new cars that are energy efficient with modern engines that are less polluting. It is reported that the number of car assembly plants increased from 2 in the 1960s to 18 in the 2000s, (3).
- Since 1980s and progressing fast: many parking garages have been built in the CBD and also in other major activity centres and this contributed much to the improvement of parking problems and hence reduced traffic delay of cars moving on the network just to search for parking places.
- Since 1990s and progressing fast: CNG Taxis have increased dramatically as mentioned earlier (46) and further discussed below.
- Since the late 1990s and progressing fast: Air Con Buses have also increased modal shift from the private car as mentioned earlier.
- Since 1995: the Ring Road was completed banning through traffic from entering the centre and congesting its street network as mentioned above.
- 1990s to 2000s: new traffic corridors are being introduced till 2009. Those on many instances helped in releasing some bottle necks on the network but also in the same time in some are seen to be causing some prolonged queues, particularly if car breakdown takes place and temporarily closing one lane.
- 1987 & 1994: Metro Lines 1 and 2, respectively which have certainly contributed much to fuel saving and reduced emissions as analysed in Section 7.
- Since 2001: Al Azhar car tunnels were opened to by pass Old Cairo and thus released many traffic problems along their corridor.
- 2006: Metro L3 construction started in phases I and II.
- 2009: Design and tender documents preparation of Phase III of metro L3 and Phase I of metro Line 4 for immediate contraction after the opening of Phases I and II of Line 3, as the government is committed and determined to explained this environmentally friendly system that is vital in grand metropolis like GC.

8.2.3 Main Energy/Environment Mitigation Policies and Projects

- In 1982 the first governmental agency for the environment was established, namely Egypt Environmental Affairs Agency (EEAA), and it was linked to the Prime Minister Office. EEAA has a special branch focusing on GC environmental affairs.
- In 1994, the first Environment Law (Law No. 4/1994) was approved and applied.
- In 1997, the first ministry for the environment was established, namely The Ministry of State for Environmental Affairs, and EEAA was immediately integrated under this ministry.
- 1997/2004 EEAA/USAID Cairo Air Improvement Program (CAIP). This program includes different components;
 - Vehicle Emission Testing (VET) including: vehicles testing in workshops, on the road and in fueling stations with more than 50000 vehicles tested, supporting the creation of the national programme for vehicle inspection at traffic police licensing centres for the vehicles that do not pass the emissions limits of the Environmental law. The programme started in Giza and Qalubia in 2003 and is now applied in many other governorates.
 - Providing 50 dedicated CNG public-transit buses to the CTA and GCBC.

- Supporting emission testing and engine tuning of diesel public transit buses in Cairo. A comprehensive air monitoring system for greater Cairo has been fully operational for five years.
- CNG Vehicles: in December 1994 the first company to convert gasoline vehicles to natural gas was formed and by the end of 2005 this number was raised to six operating CNG companies. In total, 93 CNG fuelling stations and some 63000 CNG vehicles are currently in use, 75% of which are taxis, mainly in GC. This represents about 3% of the world CNG vehicles, which is quite considerable for GC.
- EEAA Pilots project of the replacement of old taxis with new ones, through arrangements with banks has started in 2007 followed by the new traffic law that was approved in August 2008 which prohibits licensing of taxis more than three years old, with a period of grace of three years, ending August 2011.
- Along the same foot steps, on 5, March, 2009 the National Project for Renewal of Old Vehicles has been announced by the Ministry of Finance. The project started on 8 March, 2009, and aims at abolishing taxi cabs of more than 30 years old which amount to about 34000 vehicles and replacement by brand new ones. The old vehicles will be totally obliterated so that they will no longer appear on the street network as private cars, etc. The three major banks will participate with the loans and five local car assembly companies of famous car makes will also participate offering 30% reductions on vehicle service big incentives. Other incentives are guaranteed as waiving sales tax and customs on the new vehicles and allowing advertising on the cabs and using the revenue to pay a five year insurance on the vehicle in addition to deducted from the initial loan.

9. Concluding Note and Report Summary

The distant history: The capital of Egypt, Cairo, is a very old city established at its present location at the spur of Al Moquattam Hills, in 969, very close to the original site of Al Fustat further south the earlier capital that was established in 640, after being named Memphis and remaining for five millenniums near the Pyramids Plateau in Giza, some 15 km to the west of Al Fustat. The population of Cairo in 980 was only 0.1 million inhabitants and in 1980 it became 8.6 million. In the late 1960s the agglomeration was named Greater Cairo, consisting of Cairo governorate, the urban part of Giza governorate and the southern urban part of Qalubia Governorate. Now five governorates share the area of GC.

Nowadays: GC region started to get its contemporary structure; a "main dense urban area" with varied socioeconomic levels that is subdivided into a "core area" and a "surrounding peripheries", both encircled by the Ring Road, and an "outer belt" of 8 new satellite cities. GC is the largest urban area in Africa and the Middle East and one of the most populous metropolises of the world. Cairo occupies the 11th rank within mega cities across the world in the period between 2000 and 2015. Over the 20th century the population increased from 0.6 million in 1900 to more than 10.5 millions in 2000. The rate of natural population growth in Egypt in 1966 was 26% and became 30.4% in 1985, and started to decrease continuously until it reached 21.8% in 1996 and 19.5% in 2006.



Reasons include the success in family planning programmes, the increased economic pressures and the eventual diversion from an agricultural society to a new era of industrial development, information technology, commerce and business.

GC population and urbanized area: have similar steady rates of increase over the years as each has nearly doubled between 1971 and 2001, while they increased by nearly 50% in the mid period, 1987, compared to 1971. It is clear that urban expansion is not easy to take place over the surrounding desert because of the high cost of infrastructure and possible difficulties of building because of geotechnical problems. In the same time, it is not easy to expand over the surrounding rich soil scarce agriculture fertile lands, for the obvious reasons. Accordingly, population density increased in 2001 by about 11.3% compared to 1971, reaching 39000 persons/km². However, informal expansion still occurred slowly over the last 40 years, and also in parallel big effort has been made since the 1980s to improve the situation.

Decentralization of activities: many policies and projects have been implemented over the past three decades to achieve decentralization of many activities from the urban core, the CBD and the density zones of GC. These ranged from relocation of major activity centres, opening new activity centers out of the above areas, giving incentives to private investors to decentralize their activities and individual efforts of activity owners and businesses to move and expand out of the high coast congested traditional centres.

Policies to ameliorate informal housing expansion: Three major policies have been implemented with success over the past two decades and differ according to the size of the informal settlement, the number of families living and the availability of replacement locations. The report discusses these policies and show examples of success. However, it is clearly understood that this effort needs time and cost, and involves complex legal and social dimensions.

The New Cities; a unique experience on the desert: If we consider the belt of the new cities around GC and how this unique experience has successfully expanded since the late 1970s, when it was first initiated, it is clear that organized expansion over the desert around GC came to be a reality after very big effort and investment from the government and lately with the participation of the private sector. Some of those cities currently accommodate unbelievable huge numbers of industrial firms and offer numerous job opportunities to young families, as well as plying big role in the national economy. In addition to the 8 new cities around GC, other 15 new cities are fast developing all over the country; all planned on the desert as the new cities policy of the late 1970s called upon. As mentioned in Section 4, it is reported (20), that the urban expansion around GC is very impressive and probably the largest urban building site in the world today.

Transport Demand and Urban Mobility Trends: Total daily trips increased from 5.6 million in 1971 to 21.6 million in 2001 and are forecasted to reach more than 30 million in 2022. Walk trips increased from 26% of total daily trips in 1971 to 32% for 2001.

Accordingly, in 2001 daily motorized trips were 14.4 million and are forecasted to reach 25 million in 2022; an increase of 174 %. Person mobility trend is increasing by time as it nearly doubled between 1971 and 2001 rising from: 0.8 trip/person, to: 1.64 trip/person; respectively. The latter is on the lower side because the study area that gives this rate included GC plus the new cities and rural centers surrounding out of the Ring Road. It is clearly observed that GC urban mobility is currently much higher than that of 2001 and that it will increase more as time grows.

Modal Shares: The share of car trips was increasing till 1987, and then a drop started to take place till 2001. This may be attributed to the rationalization of car imports in the early 1980 and also to the start of operation of metro Line 1 in 1987 and Line 2 in 1996 which attracted many car users to shift. For public transport the share of bus (and minibus) of daily trips is steadily decreasing all the way dropping from 70% in 1971 to 22% in 2001. This decline is still undergoing as compared to 3 million daily trips on these two modes in 2001, the counter number for 2008 is 2.2 million daily trips. On the other hand, shared taxi share in daily trips increased steadily and sharply as in 1987 it was 6% and in 2001 it reached 37%, capturing trips from the bus. Similarly, the share of metro in daily trips increased from 6% in 1987 to 17% in 2001, with only two lines operating. In that latter year the observed daily metro trips were 2 million compared to daily average of 2.35, and an observed record of 3 million trips, in 2008, though the network did not change much over those seven years. This again confirms that the metro has been capturing considerable trips from the bus as it did also with those made by the private car.

The Number of Cars: For precision, the evolution of the number of cars is given for Cairo Governorate alone and not for GC, based on (3). Between 1976 and 2001 the number of cars rose dramatically from about 86000 to about 625000 cars; a remarkable 727% increase! In 2007 the number reached about 960000 cars, which is an increase of 1116% compared to 1976 and of 154% compared to 2001. The evolution index between successive years taking 1976 as a base year is found to be 4.2 for 1986, 5.9 for 1996, 7.3 for 2001 and 11.2 for 2007.

Evolution of Vehicles Compared to that of Trips: The number of vehicles increased in 2001 by 14 fold compared to 1971 while the number of trips in 2001 is nearly 4.5 times more than that of 1971. This is logical as vehicle use is what counts and not vehicle number. Furthermore, this result also confirms the importance of the metro in GC, and how it reduced vehicular traffic offering an attractive alternative mode, freeing the car user from mode captivity. Obviously all metro users have converted from road-based modes when making the daily essential tips to work, particularly the private car, the taxi and the bus.

Evolution of Transport Modes and Systems: To cope with the continuous increase in motorized trips, GC transport system has witnessed great expansion and changes in type, size and location. In 1971 public transport consisted only of three modes, bus, tramway and trolley bus. Currently, in 2009, 10 modes are in operation, namely CTA bus, CTA minibus, GCBC bus, Air-conditioned bus (by CTA and GCBC), CTA River

bus, tramway, metro, minibus of private operators and the informal shared taxi minibuses and the cooperative societies' minibuses. These are in addition to the private companies yellow taxis which did not exist before 2006. The GC metro started operation by Line 1 in 1987 and Line 2 in 1996. Line 3 Phases I and II are under construction and due for operation in 2011 and 2013, respectively. Phases III of Line 3 and Phase I of Line 4 are in the feasibility and design stages and due to start implementation immediately after the opening of the above mentioned two phases of line 3, due to the government strong commitment.

Evolution of Transport Infrastructure and Facilities: The period 1971 to 2001 saw huge increase in transport infrastructure projects in, and around, GC (see Section 5). These include new Nile bridges, numerous overpasses/underpasses, car tunnels, major elevated expressways; the Ring Road, a number of grand parking garages and multistory car parks, expansion and relocation of major bus terminals and Terminal 2 of Cairo International Airport in 1985 and Terminal 3 opened early 2009.

Reduced Speeds, Fuel Consumption and Emissions: In addition to what is mentioned above, the number of small size cars in GC reached 78% of all road-based vehicles in 2001. With the difficulty to expand the urbanized area and the street network, the average operating speed is low. The result is higher specific fuel consumption and greater GHG and pollutants emissions. In 2001 GC transport sector consumed about 2.5 Mtoe and emitted about 7.2 Mt of GHG, which is about 25% of the total GHG emissions of Egypt transport sector. However, the per capita GHG emissions from transport in Cairo is only about 220 kg/capita compared to 7500 kg/capita for Atlanta, 1400 kg/capita for London, 1100 kg/capita for Paris, 950 kg/capita for Tokyo and 500 kg/capita for Tunis, which by far on a very low magnitude for global warming effects.

Evolution of Fuel Consumption, CO₂ Emissions and Pollution Gases: It is interesting to observe that fuel consumption and GHG emissions increased by 11 fold between 1971 and 2001. This similarity is very logical as both are highly correlated. Whereas, on the other hand, the evolution of air pollution gases, NO_x and CO are nearly 8 and 6.5 times more in 2001 than those of 1971, respectively. This is attributed to the less polluting new vehicles added to the road fleet in the past 20 years and the use of the environmentally friendly metro, as indicated below.

Impact of GC Metro: The use of the metro in GC certainly decreases fuel consumption from transportation. It is estimated that if the metro did not exist the annual fuel consumption is 6% higher and the GHG emissions are 7% higher, than when it is operating, as the 2.3 million daily travelers currently using the metro, will have to use road-based modes of travel instead, bearing in mind the long travel distances involved. It is estimated that this is equal to 168000 vehicles to run daily on the metro lines 1 and 2 corridors passing through the CBD, causing unmanageable traffic congestion and delay. As for CO and NO_x, in the case "without metro" they could be much higher because the electric power stations for the metro electricity uses natural gas and the results in lower CO₂ and CO emissions compared gasoline and gasoil used for the road-based transport vehicles that will be used if the metro is not operating and bearing in mind the long travel distances and the reduced speed and incurred delay.

Areas of Improvement; Doing What Works!

In this section we give highlights and suggestions on areas on which effort need to be continued and sustained and can be directed for improvement of urban quality, transportation and energy/environment. This is based mainly on the findings of the present research regarding the evolution of urban development and expansion, transport needs, demand and supply and the related impact on energy consumption and environment, as well as the long experience of GC in terms of mitigation policies and projects and possible transferable lessons and existing conditions. We focus only on practical ideas and not on theoretical or exploratory speculative ones that though may sound useful still the long experience and local realities tell they are difficult to implement. In other words: We concentrate solely on how GC and sister cities can be doing what works!

Although notable effort has been done to develop the urban structure of GC and maintain its viability, more effort is still required. The always increasing population and the different zones with varied urban fabric and different socio-economic characteristics make GC in continuous need for a drive on the road for sustainable development.

This necessitates continuing the successful policies and projects that achieved planned decentralization of activity concentrations in the past decades and the relocation of activities sited in the core, as well as in main dense districts, to appropriate sites, with ample space and efficient access, in outer areas. The private sector has a very positive roll to play in those respects in cooperation with the local authorities. Facilitation of such involvement would be a positive step.

Continuing on the successful policies and projects of the local authorities concerning impeding expansion of existing unplanned informal housing, and total prevention of more in the future, is to be encouraged. The relocation of small size central informal housing sites to better and healthier planned locations and the "on site" enhancement of large ones when relocation is impossible should continue. The full awareness of the local authorities, decision makers and the society at large are positive elements that should be capitalized as they serve as a sound base for sustainable success. More involvement of NGOs and the civil society need to be expanded as in fact a good number of those agencies have been successfully working and helping so much the local authorities in improving the informal housing areas in and around GC out of the public budget.

Improving the internal services and amenities in the new cities is also required to speed up absorbing more residents of all socio-economic levels as they have remarkably succeeded in attracting massive industries and businesses, private Universities and commercial and recreation centres. Participation of the private sector investors and companies, which has been encouraged in the past decade, complements the new cities management and the government efforts to achieve this goal.

The commitment and determination of the government in expanding the metro network is appreciated and should continue as it is vital for carrying the burden of daily transport in a mega metropolitan area like GC, with projected population of more than 22 million inhabitants in 2022. It is unimaginable what would have been the situation of traffic delay, congestion, reduced operating speed on the street network, energy consumption from road-based transport, GHG emissions and local pollutants emissions in other sister metropolises like London, Paris, Tokyo, for example, if there were only two metro lines of 80 km length in operation in each of those grand metropolises!!!

Additional effort in exerting modal shifts from the private car to metro is required and what makes this effort promising is the clear observation of the ever increasing demand on "Park & Ride" around many metro stations. The introduction of a high level of service privately operated modern bus feeders to link high income districts with the metro stations is certainly required. In addition to decreasing car traffic on feeding streets, it can reduce congestion around the stations from the excess parking demand and the unproductive driving time just to find a parking place. A pioneer pilot is suggested in reference (47).

Enhancing concession contracts of the private concession operators of public transport buses in GC can achieve more balance between the offered service quality, the user needs of reduced fare values and a good out of the fare box financing through advertising and utilizing the terminal stations, etc. This will also benefit the CTA and reduces its burden and, hence, its annual call for public subsidy. In addition, those companies should be allowed to offer quality lines in order to attract a shift from the private car and to cross subsidise their common services.

Continuing on the recent serious effort and policies of reducing vehicular fleet age in GC, and in the country at large, is yet another important requirement. Monitoring the results of the tried policies and programmes would be very useful so as to enhance and ensure their sustainability, and to encourage more non-traditional schemes responding to the real needs of the owners of the old cars and taxi cabs. This needs determination and will, which are both felt among the concerned agencies.

Not less important at all, is the continuity of the very successful experience and well tested policies of encouraging taxi drivers to convert cabs into CNG, which was internationally acknowledged when Egypt was granted the US Department of Energy award in 2005 for that achievement. The ever increasing number of converted taxis is a very good sign of a future sustainable expansion.

Investigation into the facilitation of non-traditional innovative financing for boosting the technical support of engine tuning of vehicles in GC, and also nationwide, is necessary for this effort to be sustained. Encouraging young mechanical engineering graduates to participate by opening small workshops for that purpose is useful indeed.

They can receive soft loans from social services funds, development banks and international financing agencies interested in reducing global warming, in addition to receiving tax exemptions and customs duties elimination on spare parts used for engine tuning, are but a few examples of complementary incentives. This suggestion will not only help the environment and the economy by reducing unnecessary consumption of non-renewable fossil fuels, but also would be creating new job opportunities, thus it is by all means leading to environmental, economic and social sustainability.

Closure:

Many transferable lessons from the long and rich experience of GC are presented and discussed throughout this research work report; related to the addressed three areas of interest; "Land Use", "Transport" and "Energy/Environment". As there are many land use and transport elements that contributed to traffic congestion, reduced speeds and, hence, energy/environment consequences over the past 40 years; there are also many policies and projects that brought about positive and sustainable impacts on reducing energy consumption, GHG and pollution gas emissions from transportation in GC, some of which are pioneer and superior.

So, it is believed that other sister cities in the south Mediterranean, and also from developing countries in other regions of the world, may be able to draw learned lessons; bridging the obstacles and capitalizing on the successes.

Therefore, in addition, it is vital to achieve new type of dialogue and cooperation of two types. First, south/south, where countries from the south Mediterranean directly cooperate and exchange knowledge and experience, and also education whenever needed. We share similar conditions; we bear similar constraints; we have similar hopes for sustainable development; and certainly we can, bilaterally or multilaterally, complement. Second, is south/north/south, where a third party from the north Mediterranean industrialized countries is importantly needed to participate in the dialogue so as not only to bring about the technology transfer element, but also and perhaps not less important, to play the roll of a catalyst for reaching the appropriate mechanisms for application of pragmatic solutions.

Finally, we urge future research to address analytical mathematical modelling of linking land use, transport and energy/environment, bearing in mind the intermediate position of "transport", demand and supply, receiving input form "land use" development from one hand, and exerting consequences on energy needs and bearings on environmental impacts, greenhouse gas and pollution emissions, from the other. This is though well catered for, in the industrialized countries, it is still lagging in the developing countries context where the local conditions and the prevailing constraints of cities prevent prototype transfer of results.

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