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Analysis of thirty years evolution of urban growth, transport demand and supply, energy consumption, greenhouse and pollutants emissions in Greater Cairo☆

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ABSTRACT

The objective of the paper is to analyze evolution of urbanization, transport demand and supply in Greater Cairo (GC) over the last three decades of the 20th century. This is in addition to investigating the impact of city growth on energy consumption and emissions from transport. It utilizes results of 1971, 1978, 1987, 1998 and 2001 travel demand surveys, undertaken during the corresponding GC transport studies; each was published a year or two later. No further transport studies have been carried out in GC over the past decade and in view of the current political situation, it is not envisaged that similar studies will be undertaken in the near future. The analysis includes the evolution of daily trips, trip purpose share, modal share and number of cars. More recent trends for 2006/2007 vehicle registration by type and size are given. The evolution of transport supply covers projects until early 2012. In parallel estimates of the evolution of energy consumption and cost, emissions of greenhouse gases (CO_2) and pollutants (CO, HC and NO_x) are given for 1971/2001. The adopted estimation methodology is summarized. Comparative analysis of relevant evolution indexes and trends of growth between 1971 and 2001, taking the former as base year, is given. Land use and transport policies and projects that in some cases helped, directly or indirectly, to reduce traffic congestion, or at least prevented an increase, are addressed, commenting on their outcomes. Thus, transferable experience are useful to sister cities benefiting from successes and avoiding drawbacks. The evolution of the impact of GC metro on energy consumption and cost, and GHG emissions is given for 1987/2001, assuming the scenario "metro did not exist". More recent impact analysis is given for 2007/2008, as the data allowed estimating traffic volumes that would have been added to the congested metro corridors under the above scenario; and the related fuel consumption and cost and GHGs. The paper ends with conclusions on GC evolution, learned lessons and suggests repeating similar work in other mega cities of the developing countries. Further research is emphasized, e.g., modeling the relationship between land use, transport, energy and emissions; modeling emission factors by vehicle type; and studying fuel-subsidy-reduction scenarios and their socio-economic effects.

1. Introduction

Many cities of the developing countries are growing. Increased urban population, human activities and migration from rural areas; are of the main reasons for this growth. This has bearings on increased travel demand. In the same time, it is difficult to expand transport systems and infrastructure with the same rate of travel demand growth. It is equally difficult to introduce efficient transport supply management and to apply, or enforce, travel demand management measures. This leads to negative consequences, e.g., urban congestion, increased energy consumption and greenhouse gas (GHG) and pollutant emissions.

Over the past four decades, attention of researchers, cities, countries, and international organizations have been directed to issues of traffic congestion, energy consumption, CO_2 and pollutants emissions. However, this is either made in one point of time; or concentrates on future forecasts. To contribute to that effort, it is believed that, in addition, trends of past evolution should be examined. Henceforth, we learn and understand more about the dynamics of change of urban transport and the related impact on energy and the environment.

☆ Based on research project, (DRTPC Study Experts, 2009), led by the 1st author with active participation of the 2nd.

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It is also clear that transport demand and supply are always affected, and reflected, by the extent of urbanization and activity development; by type, density and location. In the same time transport, mainly road-based modes, bears on energy consumption, increased GHG and air pollution. In other words, "transportation" lies in the middle, between "urbanization" from one hand and "energy/environment" from the other. It takes the burden of urban area expansion as a generator/driver of increased transport demand/supply; and their evolution by size and location. In the same time, transport causes direct impact on energy consumption and emissions of GHG and pollution; and also their evolution; by size and/or location. Transport, in addition, as mentioned above, has strong mutual interaction with land use activity; each is directly affecting the other.

The paper analyses the evolution of transport in Greater Cairo (GC) as a consequence of urban development and population growth and the resulting energy and environment impacts over the last three decades of the 20th century; 1971/2001. Data of five Origin/Destination (O/D) surveys were used. Those surveys were carried out in 1971, 1978, 1987, 1998 and 2001, during five corresponding transport studies that were published a year, or two, after each survey, respectively. As availability permits, however, statistics for more recent years of the first decade of the 21st century are referred to. It is unlikely however, that new transport studies will be carried out for GC in the near future due to the current political and economic situation.

2. GC evolution, 1971/2001

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 13th rank within mega cities across the world in the period between 2000 and 2015 (UNDESA, 2007). Over the 20th century the population increased from 0.6 million in 1900 to more than 10.5 million in 2000. The rate of natural population growth in Egypt was 0.260 in 1966, became 0.304 in 1985, and started to decrease continuously until it reached 0.218 in 1996 and 0.195 in 2006; marking effective family planning policies.

GC 'population' and its 'urbanized area' have similar steady rates of increase over the years. Each has nearly doubled between 1971 and 2001, while they increased by nearly 50% in the mid period, 1987, compared to 1971. Urban expansion is not easy to take place over the surrounding desert land. This is related to the high cost of infrastructure and the geotechnical problems of building on the desired sandy soils. In the same time, it is not favored to expand the built-up development over the surrounding scarce fertile agriculture lands. Accordingly, population density increased in 2001 by about 11.3% compared to 1971; reaching 39,000 persons/km^2. Consequent, problematic informal housing expansion has been occurring slowly over the past 40 years. Also parallel fragmented effort has been made since the 1980s bringing only marginal improvement, nevertheless.

The continuous growth of Cairo, later GC, population and activities resulting from development drivers, brought matching consistent increase in transportation. The evolution of "transport needs" of the residents, and visitors alike, and that of the "offered transport facilities" have always been increasing. This took place with varying trends and rates. As there are obvious problems of congested corridors, traffic delay and crowded buses during extended peak periods, there are also achievements to mitigate the consequences. Those include new elevated roads, parking garages and the introduction, in 1987, and continuous expansion of the metro network. Although some of those projects created improved access and hence, generated more trips, yet their impact on reducing congestion cannot be ignored. In addition, there are also policies and projects that aimed at saving energy and reducing transportation impacts on the environment. Section 9 addresses lessons from the above mentioned policies and projects. For detailed review of urban transport evolution and urban development in GC refer to (DRTPC Study Experts, 2009; Huzayyin, 2004).

3. GC transportation supply in 2012

Fig. 1 shows the main road network of the GC region in general; covering the new cities and the surrounding rural centers. Fig. 2 shows the main road network of GC inside the ring road boundaries. The road network is composed of a variety of road hierarchies ranging from elevated expressways forming strategic traffic corridors to collectors and local streets. Numerous alleys in the old districts expand within housing and small commercial units. A segregated Ring Road of some 100 km also exists and prevents through traffic from crossing the city. River Nile passes through the city from the South to the North; constituting major barrier between East and West districts. Sixteen bridges cross the River connecting the two sides and the main residential islands. Numerous flyovers and underpasses, by-passing main squares exist. Two main tunnels, each is 2.5 km length, under-pass Old Cairo.

Among the existing private transport modes, the private car is the most important. While among formal and informal public transport, different modes play important roles. The formal publicly owned and operated modes include bus and minibus with a network of more than 10,000 km. The main operator is Cairo Transport Authority, CTA, which runs in addition, two old tram systems and two Nile ferry lines. Twenty two private companies own and operate formal minibus services on concession lines. One of the most important formal public transport modes is the metro, operated by a company belonging to the Ministry of Transport, with a network of some 90 km. Lines 1 and 2 inaugurated in 1987 and 1996, respectively, and Phase I of Line 3 was opened early 2012. Informal public transport includes the, mostly 11 seats, "shared taxi", microbuses and the 25 seats "cooperatives" minibuses. Benefiting from the small vehicle size and being operated by individual drivers/owners, the shared taxi is a demand responsive mode that is heavily used.

4. Evolution of transport demand and supply, 1971–2001

The results of the O/D surveys of GC transport studies (JICA, 1989, 2002a, 2002b; SOFRETU, 1973; SYSTRA/DRTPC, ACE & IAURIF, 2001a); were utilized. Analysis of transport demand evolution figures and trends are based on a number of assumptions that allowed comparisons on equal grounds (Huzayyin, 2004).

Total daily trips were 5.6 million in 1971 and rose 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 covered in the 2001 O/D survey compared to the earlier ones. It is estimated that the number of daily motorized trips in 2022 will increase to about 25 million (JICA, 2002a), which is nearly an increase of 174% on the 14.4 million motorized trips observed in 2001 by the same reference. A recent estimate for 2009 motorized trips is given as about 17 million (SYSTRA/DRTPC, 2010).

Person mobility nearly doubled between 1971 and 2001; rising from 0.8 trip/person/day (SOFRETU, 1973), to 1.64 trip/person/day (JICA, 2002a), respectively. In 1998, this rate reached 1.42 trip/person/day (SYSTRA/DRTPC, ACE & IAURIF, 2001b). Thus, it is clear that urban personal mobility is increasing by time. It should be noted, however, that the mobility of 1.64 trip/person/day reported