ANALYTICAL AND COMPARATIVE STUDY ON SUBWAY SYSTEMS OF CAIRO AND SAPPORO*

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1. Introduction

The construction of a rail transit system (RTS), especially a subway usually faces worldwide controversy, as it requires huge investment that usually impedes its application even when needed. The situation is worse in mega cities of developing than developed countries due to the lack of financial resources and insufficient surface transportation infrastructure. Moreover, almost all applied rail rapid transit (RRT) systems face serious financial problems and/ or declined level of service (LOS) that made them always in need of subsidy[1]. These problems are mainly due to shorting in planning, design or implementation of the system. This paper highlights the importance and the feasibility of such systems to megacities of developing countries.

2. Objectives

The study has two main objectives. The 1st objective is to study the difference in urban and transportation characteristics of Cairo and Sapporo to show the crucial need for such a system in Cairo. The 2nd objective is to evaluate the subway system in Cairo in the light of the Japanese experience. This paper discusses the results of the comparisons and propose directions for further research of the RRT systems in general and subway system in particular.

3. Analysis stage

(1) Type of data and data processing

To handle the pertinent data for the comparison, it was important to identify the factors affecting the economics of the RRT systems and related to transportation. Data was gathered from different sources using documentary searching method in both Egypt and Japan. Analysis of the screened data followed an adopted comparison framework.

(2) Framework of the comparison

The structure of the comparison is composed of the following main elements:

- Urban characteristics
  - Urban growth
  - Urban composition
- Transportation characteristics
  - Transportation demand
  - Transportation supply
- Subway system characteristics

4. Comparison Between Cairo And Sapporo

Generally, the conditions implied the application of subway systems differ from developed to developing countries[2]. In Japan, urban rail transit systems did not aim at reducing the private car-use directly. Rather, it aimed at reducing congestion to encourage motorization. Therefore, most of subway networks have been built to replace the tramway routes or bus routes while suburban railway have been constructed together with development of new towns.

(1) Urban growth:

The expansion of Greater Cairo Metropolitan Region (GCMR) reached its ultimate that the total as well as the residential areas of GCMR have not changed since 1976. Moreover, starting from 1976 the population growth rate in GCMR has been less than that of Greater Cairo Region GCR and also less than the normal increase rate although it was the biggest in the period from 60 to 66; and it had the same growth rate as GCR bigger than the normal in the period 66-67. This reflects the saturation of activities and full urbanization with high population density. Comparing the population density as well as the road / total area ratio of GCMR and Sapporo gives the impression of the severe crowd in GCMR and the lack of surface transport infrastructure. In case of Sapporo, the DID area and the population growth expanded to 150% & 124% respectively from 1975 to 1985.

(2) Urban composition:

In case of Cairo, schools and shopping areas are well distributed that 58% and 68% of their trips respectively are carried out by walk. Regarding work- purpose, 30% of the trips are carried out by buses while 20 % by private cars.
In case of Sapporo, almost 25% of the total trips in Sapporo is done on foot. The city enjoys good land use distribution in terms

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of residential areas, schools and shopping areas that about 65% of the on-foot trips are to school & the rest for shopping. Above 40% of the total trips by private cars is for work purposes.

Table 1: Comparison of General urban characteristics between Cairo 1986 and Sapporo 1990

Criteria	Cairo	Sapporo
Total area km2	642.24	1121
DID area km2	642.24	202.4
ratio of DID / total area	100%	18%
Net population density (person/km2)	13444	8681
Gross population density (person/km2)	13444	1567
Area of roads/total area km2/km2	2.90%	5.90%
Total area of roads/1000 persons km2	0.002	0.036

Table 2: Comparison of modal share between Cairo and Sapporo

Mode	before RRT introduction		after RRT introduction	
	Cairo	Sapporo	Cairo	Sapporo
	1986	1972	1995	1983
walk	37.8	42	n.a.	25.7
public modes	28.4	23.2	n.a.	19
taxis	5	n.a.	n.a.	5.2
p. cars	20.4	29.4	22	40.9
others (non-motorized)	8.3	5.4	n.a.	9.2

(3) Transport demand:

Without the subway system in Cairo, the share of the private mode was expected to be double that of public modes and the aggregated average speed was expected to decline to 4.4 km/hr from 7.3 km/hr in 1987 when the modal share was equal. Before the introduction of subway system the modal share was nearly the same in both Cairo and Sapporo. After the introduction, the modal share in GCMR did not change greatly as the main change in the ridership was mostly among public modes. Regarding GCMRL, the estimated no. of passengers who commuted by the regional line for the year 1990 (according to the French studies) was 311 million passengers, while the actual number was 233 million (the difference stands for 214000 pass/day). One of the main reasons for this was the increase in p. car trips, which were estimated to be 1.056 million for the year 1987 according to the French studies, while the actual number estimated by JICA in1989 was 2.802 million daily trips.

In case of Sapporo, while walking trips decreased, short-distance trips by non-motorized modes have increased after the subway introduction. These trips are mostly feed trips from/to the stations. From 1972-1983 share of public modes has decreased while that of private cars has surprisingly increased despite the amazingly quick introduction of RRT systems (subway and p. railway). This can be attributed to the expansion of the DID area out to the suburb with the increase in population while subway lines are mainly constructed in the DID area. Other factors include the flexibility of p. cars and its incompetent accessibility to most of the places; the non-congested roads due to the low demand/capacity ratio; and the decreasing volume of buses, trams & the slight increase in number of taxis. It need not mentioning that a portion of that increase in car ownership is normal owing to the increase in living standard and the rise in the individual's income.

(4) Ridership of public modes

In breaking down the demand of public modes before and after the subway introduction: the demand share of bus mode was almost the same in both cities although the demand volume for bus in Cairo is much bigger compared to that of Sapporo. This is quite clear by comparing number of passengers per km traveled (15:1 respectively). Considering the bigger population volume and the less percentage of roads in GCMR, that confirms the existence of severe congestion in GCMR. After the subway introduction, bus modal share decreased significantly in Sapporo while it was increasing in Cairo. In case of Sapporo, the decrease in bus demand principally resulted from the increasing dependence on cars for the reasons mentioned before in addition to the rearrangement of public transit services, which led to a curtailment in bus lines as well as a decrease in its demand. With reference to Cairo, on the contrary, the increase in bus demand is related to the improvement of the coordinated system by providing bus service in other areas lacking adequate transit supply. Therefore, it is very important to realize that the subway system can not solve the congestion problem in all zones of the region but on corridor basis.

Regarding LRT & taxi modes: LRT ridership was considerably big in case of Cairo (17%) rather than Sapporo (6%) but the average trip length was much less in case of Cairo. After the subway introduction, LRT and taxi demand dropped in both cities. As a conclusion, in the case of Cairo the shift from LRT and taxi modes was equally to bus and RRT systems. In the case of Sapporo, the shift from bus and taxi systems was mainly to subway system with less share to railway system.

Regarding the subway, the need for such system in Cairo was a necessity as the number of passenger/km is around 22000/day as in 1995 while that of Sapporo is about 14000/day for the same year despite the steady increase in subway passenger volume and the decrease in case of surface transit modes. On the other hand, the average trip length by Cairo Metro is almost three times that of Sapporo. This shows the efficiency of the Cairo metro system and the success of choosing its route as it took the advantage of the great demand previously grown along the route of the two urban railway lines, which were replaced by the regional metro line. Although this may not represent a significant value from the view point of transport, it is a vital factor to consider in implementing such an expensive system in such a developing country with limited financial resources in order to maximize the operator's benefit and effectively relieve the crowd of other modes where it is impossible to increase its volume without more deterioration of the traffic condition.

(5) Transit supply

Considering the lower ridership in case of Cairo Metro, which is 1/3 that of Sapporo and knowing that the network density in

Sapporo is about three times that of Cairo, this leads to the conclusion that the modal share of subway, with respect to other modes, is directly proportional to the network density. Moreover, knowing that the productivity in terms of car.km/ km of Cairo subway is 1.7 times that of Sapporo, this leads to the conclusion that the productivity of the system is directly proportional to the demand per km of the line and has no relation with the network density.

(6) Evaluating the efficiency of the metro system in Cairo

Regarding employment characteristics, number of workers per km of line in case of Cairo exceeds three folds that of Sapporo but the number of passengers per employee in case of Sapporo is almost double that of Cairo. Moreover, the productivity in terms of passenger.km/ employee in case of Sapporo is almost 8 times that of Cairo, at less than half the labor cost in terms of car.km/ employee. Those facts indicate that the employment system in Sapporo subway is more efficient than in Cairo subway.

Table 3: Comparison of public transport demand between Cairo and Sapporo

Criteria	Cairo	Sapporo
Before subway introduction	1986	1970
Bus system		
% ridership	68	59.6
no of daily pass/ km traveled	93	6
no of pass.km/ day (1000)	47800	
average trip length km	8	
LRT system		
% ridership	17	6.9
no of daily pass/ km of line		4900.16
no of pass/ km traveled		14.4
no of pass.km/ day (1000)	2630	n.a.
average trip length km	5.5	12.5
Taxi		
% ridership	15	33.5
After subway introduction	1995	1995
Bus system		
% ridership	81	28
no of daily pass/ km of line		467
no of pass/ km traveled		4
Subway system		
% ridership	13	42
no of daily pass/ km of line	22040.3	13860
no of pass/ km traveled	12.5	7
no of pass.km/ day (10E+6)	14.2	
average trip length km	15.17	5.6
LRT system		
% ridership	6	2
no of daily pass/ km of line		3027.5
no of pass/ km traveled		8.69
average trip length km		4.2
Railway system		
% ridership		12
no of daily pass/ km of line		3017
no of pass/ km traveled		9
Taxi		
% ridership		16

Table 4: Comparison of public transport supply between Cairo and Sapporo

Criteria	Cairo	Sapporo
Before subway introduction	1986	1970
Bus system		
daily no of bus/1000pass	0.671	
average speed km/hr	7.1	
LRT system		
network density km/km2		0.26
daily no of cars/ 1000 pass	0.43	0.35
daily productivity car.km/ km line		502.28
average speed km/hr	8	
Taxi		
daily no of taxi/1000pass	5.84	15.41
daily productivity km/taxi		288.3
average speed km/hr	8.4	n.a
After subway introduction	1995	1995
Bus system		
network density km/km2		2
daily no of bus/1000pass	0.91	1.9
daily productivity bus.km/ km line		117.39
Subway system		
network density km/km2	0.083	0.223
daily no of units/ 1000 pass	0.317	0.293
daily productivity car.km/ km line	3481.2	2039.42
average speed km/hr	34	34
LRT system		
network density km/km2		0.042
daily no of cars/ 1000 pass	0.483	0.534
daily productivity car.km/ km line		351.24
average speed km/hr		
Railway system		
network density km/km2		0.1
average speed km/hr		
Taxi		
daily no of taxi/1000pass		21.72
annual productivity km/taxi		274.76

However, for fair judgement, the comparison should consider other factors such as the facilities provided in both sides. In case of Sapporo, it has more facilities such as ticket vender machines and fare adjustment machines, which can be translated into saved number of labors. On the other hand, the difference in passengers' attitude entails the operating system of Cairo subway to assign more labors for better control, especially when the labor force is redundant at low cost. The same can be said for other subway systems in developing countries. However, the more labors are planned to be hired, the bigger space is required to be provided at the stations, and that definitely will be reflected directly on the capital cost of the stations and also on the operating cost. In essence labor force is determined by many factors that should be compromised to gain optimum benefit at lower cost.

5. Main Conclusions And Recommendations:

The comparison revealed that it was extremely vital for a city like Cairo to introduce subway system despite the great opposition it faced. However, being a city in a developing country entails the adaptation of the subway system to match with the domestic conditions. Among the recommended measures to be considered for the adaptation are the use of the available

human resources at a very low cost; making advantage of the available less efficient transport infrastructure; and the avoidance of the luxurious accessories or facilities - for both stations and rolling stock- which provide the system with extremely high LOS as compared to what other modes provide.

It is very important to realize that better transport service may not always attract people from using their p. cars. So generally, the introduction of RRT, despite its huge capital investment, does not guarantee the attraction of passengers from other modes, especially private cars. It is true also for a subway system that it cannot by itself limit the growth of car ownership neither limit its use. Although the previous statement is true, it should be kept in mind that studying the change in modal share of the city/ region, as a whole will not give sound impression about the effect of the newly introduced RRT system, which is limited to its corridors and its surroundings especially if it constitutes a small network. This fact is of great importance in two aspects especially for developing countries with their limited financial capabilities. First, the introduction of single line of an RRT system will not solve the city/region traffic problems but on corridor basis. Second, it could happen that after the system introduction the targeted results are not realized. Therefore, it is recommended to consider all, economical and social factors in the feasibility study and analyze the risk of not meeting the expected goals otherwise it will be better from the planning stage to set counter measures to guarantee achieving the desired results.

Table 5: Characteristics of subway systems in Cairo and Sapporo

Criteria	Cairo	Sapporo
General characteristics		
no of lines	2	3
route length km	53.5	45.2
% underground	24%	100%
Average station spacing (km)		
in underground part	0.9625	1.03
in other parts	1.235	
year of introduction (of 1st line)	1986	1971
System productivity		
no of pass/ all passenger (ridership)	0.13	0.42
no of daily pass/ km of line*	22040	13860
no of pass.km/ km of line (in 1000)	122000	
employment		
no of workers/km of line**	88.58	26.06
no of 1000 pass/employee/ month***	9.81	16.22
no of pass.km/ employee/ month	11747.55	90830.84
no of car.km/ employee/ month	1080.38	2386.74

*: This figure ranges between 11000-36000 in case of Latin American metro systems

**: This figure ranges between 58-232 in case of Latin American metro systems

***: This figure ranges between 06-15 in case of Latin American metro systems

It was shown by the comparison that the financial performance of Cairo subway is satisfactory when compared with the financial performance of subway systems in the Japanese cities. Also it was shown that despite the privilege of better control with less labor force the cost recovery ratio for the subway system is fairly bigger than for other modes only if the depreciation cost is excluded. This necessitated advanced analysis to investigate the reasons behind that for its great importance in controlling the economics of these widely urged systems. Finally, some of the reached conclusions regarding the average trip length and the network density are believed to be useful for the planning and/or the evaluation process between some networks of an RRT system.

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