CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1. Introduction

The present study is basically a collection of research explorations in the area of urban public transport planning for the cities of less developed countries. The Chapter 1 starts with an elaborate description of the typical characteristics of urban transport problems in those cities. Through the peculiar characters of high and rapidly increasing population growth, high dependence on public transport, suppressed demands, low service qualities, deficiencies of conventional transport services, private ownerships of public transport, huge influx of intermediate transport modes, mixture of wide variety of transport modes, high rates of accidents and so forth, it was highlighted that problems of public transport in such cities are somewhat different in nature compared to those in the cities of advanced countries.

In the second chapter, merits of the conventional planning techniques were explored. It was experienced that the developing world are in crying need of short term immediate improvements in the transport system rather than conventional long term plannings as have been carried out in the advanced world. It was argued that because of heavy financial shortages, uncertainties
in political stability, strong influence of political parties in public decision making, poor qualities of existing transport, planning models for the cities of LDC should likely to have the following characteristics,

1. Low cost and short term
2. Aim at more quick tangible benefits
3. Smaller, simpler and less ambitious
4. Flexible
5. Low-capital improvement models, rather than high investment installation models
6. Special purpose models, appropriate to take care of specific problems
7. Provisions for participation of different interest groups at various levels.
8. Interactive and graphic capabilities for better understanding and conversing with the models.

8.2. Scope and Objective of Study

Following the above ideas, it was revealed in the Chapter 3 that in such situations, there are necessities of short-term problem solving types of models, as subsets of one global master plan, where the master plan is nothing but a broad guide line of the system as a whole. Such alternative form of planning basically has the following components,

1. Identification of critical problems
2. assignment of priorities to problems
3. solution of the problem with highest priority
4. implementation and monitoring of the solution
5. recursion of steps 3 and 4 for problems with lower priorities.

At this stage, more specific scope and object of the research was identified. It was proposed that the research would concentrate on one such typical transport problem for the purpose of a detail study. The problem of multiple modes in supplying similar types of services was chosen for the study. The research questions posed were, for any such city,

1. Is the present multimodal transport supply adequate?
2. Are all the modes equally contributing to the City's transport or there is a dominating mode(s)? What is the reason for dominance?
3. Are all the modes financially viable?
4. Are the passengers happy about the modes?
5. Is the present combination a good one? If not, what may be the better solution?

In fact the last question is the most important one, where the answers to the rest questions are already
implied. It was also felt that evaluation of any transport system of the cities of our interest depends on a number of criteria or objectives, which are required to be considered with due care. Examples of some such criteria are,

1. Level of crowding in peak hours
2. Average operational speed
3. Rate of road accidents
4. Financial efficiency of transport operators
5. Utilization of road space
6. Average cost of travel per km.
7. Rate of energy consumption
8. Employment through public transport, etc.

In this context, the concept of "modal performance levels" became useful to compute such transport objectives. It was argued that each mode may be evaluated in terms of a number attributes, expressed as performance parameters of various kinds. It was felt that appropriate modal performance parameters, suitable to the context and more meaningful in the less developed countries would be the following,

1. Service parameters, including average operating speed, average access distance, regularity of service, comfort, average daily service hours, dealings of operating staff.
2. Operating parameters, including fleet utilization, average kilometerage per day, average passengers per day, average operating cost per km., financial viability.

3. Social parameters, including accident rate, traffic violation rate, road usage rate, employment generation rate, energy consumption rate, etc.

8.3. Study Area

Arguments were made in the Chapter 2 that transport problems are very much case specific, rather than generalised, as a number local variables and constraints crowd the situation in such a way, that they can never be ignored. Thus the problem solving techniques need to be more case oriented and hence appropriate to the specific problem. On these grounds the city of Calcutta was chosen as our study area for the research. This city possesses all the typical characteristics of a Third World City and is hard pressed with numerous problems of urban transportation, including the one of our interest.

In Chapter 4 detailed study of the study area was carried out. It was experienced that the following road transport modes of the city have substitutability property,

1. CSTC Ordinary Bus
2. Private Bus
3. Tram
4. Mini Bus
5. Special Bus, operated by the CSTC

The Calcutta State Transport Corporation (CSTC) and the Calcutta Tramways Company Limited (CTC) are the two public sector transport houses of the city. Private Buses and Mini Buses are operated by private individuals in most informal ways. The basic findings were the following,

1. Although travel demand in the city is high, passenger carrying rates of the CSTC buses and the CTC trams are considerably low. This observation highlights the existence of competition in the market faced by CTC and CSTC.

2. Both the CTC and the CSTC are suffering from problems of over-employment. As a result the operating costs are markedly high.

3. Also in these organisations, the physical output rates, in terms of vehicle kilometer-age, passenger-kilometers etc. are comparatively low because of old vehicles, financial shortages, administrative inefficiency etc.

4. Because the fare rates are deliberately kept by the government at low levels also because of the poor output rates, both the CSTC and
the CTC incur heavy losses every year which become the liability of local government.

5. On the other hand, private bus and mini bus are the two privately owned transport modes, which run on profit. Intensive profit motive of these two modes induces hard competitive attitudes both in cost reduction and revenue generation processes. The operating staff are hired on casual basis at very low rates. The inferior quality of spare parts are used. Services are demand responsive resulting in no services during early mornings and late nights when demand is too low to break even. On the routes, these vehicles exert positive efforts in collecting maximum possible passengers during a trip. As a result, the common ill-effects of rash driving, frequent over taking, stopping at any point on the road, hanging back etc. are observed.

6. In spite of such traffic irregularities, fortunately the accident rates are not so severe in the city. In fact, through strong and active control of the traffic police, it was observed that the accident rates have been declining throughout the past few years.
On detail investigations of the behaviours of these transport modes in the mixed traffic, interesting facts were gathered. It was observed that

1. Proportion of existing supply capacities of individual mode in the transport mix varies significantly with space.

2. Loading levels of basic modes are in general are much higher than those of premium modes when the system is not so crowded, eg. in slack hours.

3. When crowd builds up, virtually there is no significant difference among the loading levels of different modes. They all are equally crowded.

4. Trams, although they are considered to be low-fare basic mode, are not adequately loaded in slack hours, as they are slow and unreliable.

5. A number of datasets, collected at different locations, support all the above facts, showing the nature of loading pattern is homogeneous in the city. But there were significant differences in the absolute values of load factors at different locations.
8.4. Dynamic Modal Demand Model

It was examined and experienced that at any time and space the load factor ($L_m$) of any mode $m$ in the mix, was dependent on traffic environment at that time, e.g. aggregate demand and volumes of supply capacity of individual mode at given time and space. Regression models of the type

$$L_m = A_0 + b_1 L_o + b_2 H + \sum_m d_m C_m$$

where $A_0$, $b_1$, $b_2$, $d_m$ are constants

$L_o = $ Overall load factor

$H = $ Hourly demand

$C_m = $ Capacity share of the mode $m$ at given time and space.

were tested for individual mode at different locations and statistically significant relationships were obtained.

8.5. Public Transport Composition Model

On studying the aggregate demand patterns at various locations in the city, the following facts were revealed

1. Aggregate travel demand has a positive long term trend. But slope of the trend is reducing sharply indicating saturation and only marginal demand increase in the city over the future years.

2. Considering the short-run period and local demands,
a. Volumes of aggregate travel demands vary significantly with space and time.

b. Given a location and the time-span of the day, nature of aggregate travel demand may be assumed to be stable for any week-day. The reason is because most of the travels in the city are production oriented and hence regular in nature. As the city has been moderately saturated, not much increase in the travel demand is expected over the time in the short-run.

From the supply point of view, it is experienced that the entire supply of different public transport is virtually regulated by government agencies, directly or indirectly. The governmental departments and agencies have somewhat indirect control over the system through licensing route permits, opening new routes or abolishing existing ones, etc. Also the CTC and the CSTC are public sector bodies, which operate vehicles and provide transport services directly. This being the situation, we see that the supply side is rather as control variable and though relatively inelastic because of 1) financial stringencies of supplying agencies, both private and public, 2) physical constraints of town planning and 3) bureaucratic decision making, yet supplies of different transport modes are policy variables in the hands of the policy makers.
Considering the above phenomena, we confront a situation, where demand is a stable function of its relevant variables and the supply is relatively an inelastic function, where responsibility of adjustment lies on the supply side. The conceptual framework of our model is thus as the following:

Now, in the existing system at a particular location aggregate demand with its time distribution over the day is stable and the supply capacities of transport modes are also stable (for the existing route structure). Although the system is at work, we may accept this as a feasible solution, but it may not be the optimal one, as we have argued in the Chapter 3 that an efficient and socially acceptable transport system must possess the qualities, which satisfy the overall objectives of the public transport system. A set of parameters, defined as performance levels, were identified in that chapter, which contribute directly to the objectives of public transport. The detail study on evaluation of the performance levels of each mode of our interest was carried out and described in the Chapters 5 and 6. It was observed
from the study that performance levels of any individual mode vary mainly with space significantly. For example, operating speed, irregularity index, frequency, rate of fuel usage, occupancy rate, all have significant bearing on location of the city. Hence it was necessary to restrict the problem in micro-level, which considers only a single location or stretch of road, where local values of the attributes may be considered. Let us consider that at a particular location or link, the composition of public transport that exists, be described by the vector

\[ X^o = \left[ x_1^o, x_2^o, \ldots, x_M^o \right] \]

where \( x_i^o \) is the existing activity level in terms of number of allotted vehicles, which are supposed to pass through the link, in case of mode \( i \).

Then we may define the outcome of the composition as

\[ Z^o = \left[ T_1, T_2, \ldots, T_n \right] \]

where \( T_j = \sum_{i} C_{ij} x_i^o \), the contribution for the \( j \)th parameter.

and \( C_{ij} \) = level of performance of attribute \( j \) for mode \( i \). This may also be thought of as, per unit outcome for attribute \( j \) and mode \( i \).
Then it was argued that any composition of transport modes, say X, would yield an outcome vector Z with size n, where n is the total number of attributes. The relationship is given by

\[ X \rightarrow Z \]

It was also argued that there is one-to-one relationship between X and Z. Thus the relation \( X \rightarrow Z \) may be assumed to be reversible.

Therefore the objective of the exercise was to choose such a Z, which was optimal (Say \( Z^* \)) and the corresponding composition (Say \( X^* \)) became the optimal solution to the problem.

8.6. **Solution and findings**

The model thus turned into a multi-objective type, where a number of criteria were to be simultaneously considered. Also considering the various interest groups eg. government, operators and users, to take part into the decision making process, the problem structure became one of the "Multi-person multi-criteria" type, according to the classical literature of optimization theory.

Although any of the established techniques could be applied to solve our problem, one needs to consider the fact that the adapted technique could be easily interpreted to all the groups of decision makers. In this particular case "Spread-sheet" based model was used to generate alternatives and simulate the corresponding outcomes. On generation of a set of alternatives,
The expert opinion of the decision makers were sought and compared with the alternatives. The alternative which showed least deviations from the "expert opinion values" was chosen as the best possible supply composition among the generated alternatives.

The stretch of College Street (an important link in the City) was chosen for our experiment. The stretch is served by 3 CSTC routes, 3 private bus, 5 minibuses, one special bus and 4 tram routes. It was found from the experiment that alternative compositions exist which may improve the transport efficiency of the system.

8.7. Conclusions and Important Observations

8.7.1. Present Decision Technology and the current study

Muller-Merbach in one of his current papers (1) highlighted clearly the present role of operation research by quoting "The role of operational research is to evaluate the decision and alternatives, or even to suggest decision". The need for "Social Operational Research" (2, 3) in handling complex and messy situations of any social system has been felt by many planners and analysts. The supporters of SOR do not tend to think problems in the mathematical way, but their knowledge refers to social system, they tend to think in decision processes and appreciate the messes of reality. According to Merbach, the SORs are fascinated

by people and their interactions and feel challenged by real problem situations. The abuses of complex mathematical models in the decision analyses have been strongly criticised by Ackoff (4), with the words, "Eulogies are delivered in which accounts are given about how messes were murdered by reducing them to problems, how problems were murdered by reducing them to models, and how models were murdered by excessive exposure to the elements of mathematics." According to Ackoff messes arise from social systems of any kind. They are some sort of unstructured reality.

The present study of ours, however, followed the doctrine of SOR. The entire study on the modal composition was based on fact finding, data gathering, for proper understanding of the situation and for exploring typical realities of the system. The approach in the study was rather to solve Calcutta's problem than to solve any general problem of similar kind. It was repeatedly spelt out that our system, situation, problem and model were very much case specific and not generalised ones. We have met with some common peculiarities among the transport systems of the Third World cities in Chapter I. But when we went deep into the problems of Calcutta (Chapters 4, 5, 6), we found out the city's own peculiarities and also significant variabilities of such peculiarities through space and time. Based on such information only, the working


model was developed in the Chapter 7.

In the study, emphasis was given more onto the situations and decision processes than onto abstract mathematical modelling. Instead of prescribing any decision to the planners, only the alternatives were evaluated and placed before the decision makers for their subjective judgements. In fact, our study attempted to make a SOR type of approach in handling the problems of transport systems of Developing countries.

8.7.2 Implementation and Feedback

The chosen decision (the best composition of modes) may be implemented immediately as this does not call for much capital investments or other constraints. Also it may be pointed out, since most of the travels are regular in nature in the city, the time period of users' response to the augmented system is expected to be relatively short and hence the feedback may be collected by the planners without waiting for long. Depending on the feedback and analysing the system further, some realigned decision may be arrived at and implemented. Thus transport improvements may be established through short interval feedback control loops.

8.7.3 Limitations and Further Scope of Research

Because of time and other resource constraints the present study has some limitations, which could be overcome with further studies on the following aspects;
1. Factors like government subsidies, social cost of operating staff of privately operated modes, environmental pollution, etc. were not considered because of various resource and time constraints (in our micro-level model), yet their importance cannot be ignored in the real-life problems, while evaluating macro models for the city as a whole.

2. The composition model described in the study used average values of variables (e.g., demand, supply etc.) to simulate the outcomes of a given state. But it is experienced that variables are random in nature and hence stochastic simulation is called for to simulate the situations in more realistic way.

3. Only a single stretch of College Street at micro-level, was studied and evaluated in the present research. But a macro solution for the city as a whole is necessary to be worked out. This may be done by integrating the all possible micro-models in a consolidated form, taking into account the boundary conditions of the links of the micro-models. This is a subject of further research and one can explore the merits of various ways of assembling the micro-models of the entire city.

4. It was experienced that in our study area the generalised cost models of modal split do not hold good and more dynamic choice models like the ones
developed in our study is suitable. These regression models revealed interesting facts for different locations. There are ample scope of research to look into the situations and find out the characteristics of the explanatory variables with further analyses and observations.