Chapter 3

Methodology of Study

3.1 General

This chapter summarises the methodology adopted for the study. Three steps described here are used to make a platform for the research, by which the final result of technical and financial feasibility of Water Transportation in Colombo Metropolitan Region is ascertained.

Step1 Identification of The Study Area and the Water bodies

The study area; Colombo Metropolitan Region is re defined in to three sections; Northern, Central and Southern under which, waterway systems and boundaries of influence are defined. Water bodies are identified under each study boundaries forming a continuous link between inter city and key inter nodal locations by water.

Step2 Literature Review

The waterborne transport networks in the world, particularly in the Asian region are reviewed to find the capacity on which they operate. The historical background of the identified water bodies in the CMR are studied to find its use as a transport link in the past and to identify why and how the links failed to continue as a transport system.

Step 3 Identification of the Existing Physical Condition of Waterways.

A database is formed on the identified waterways on the existing physical conditions such as access to the waterways, navigability, horizontal and vertical clearances of bridges & other obstacles across and social & environmental conditions of the areas. In addition travel time surveys on the water bodies and the road network around the canal corridor are obtained.

3.2 Technical Feasibility

The waterway systems that have suitable physical conditions and characteristics for transport systems are identified and the routes that have the basic characteristics for a sustainable canal transport system is analysed on its feasibility as a public transport mode while the elimination of the other systems are justified.

Further study in to the existing passenger movements, influence on present transport network, access to the waterway, connection to key locations; transfer to other modes of transport and other key factors together with the potential for saving on travel time and travel distance which are the benefits for the passengers and operators are used as the criterion to determine the technical feasibility for selecting waterways systems.

3.3 Financial Feasibility

For a complete financial feasibility to be obtained the passenger demand for the waterway system and the boat operating cost should be available. But in the absence of such data or demand estimation models for waterways and data on boat operating costs above objective cannot be met. However, some assessment of financial feasibility based on estimation of modal share and a feasible vehicle operating cost (VOC) for boat will be presented for the best waterway system identified under the technical feasibility.

3.3.1 Demand Estimation

The only demand estimation model available for the CMR is TRANSPLAN V.4 developed by the University of Moratuwa. It is a demand estimation model for private and goods vehicles, which is still under development to be used as a multi modal transport model including public transport. Thus it cannot be used at the present stage to estimate the demand for waterways.

3.3.2 Modal Share on Waterway

The hypothetical generalized cost function derived later, along with the binary logit model is used to determine the modal share on waterway for travel between two nodes. The binary logit model, which determines the modal share on two alternatives as a function of the generalized cost of each of the modes, do not consider users 'captivity' to their modes which is a dominant feature for car users while it is to a lesser extent for bus users. Some car users are unused to public transport while some others are compelled to use the car as the only mode due to concessions from working places, yet others the insecure feeling of travelling on water, make them captive to their modes of land transport.

The analysis for the potential modal shift from cars to waterways is obtained assuming the boat to having the same level of service as cars where the boat is taken as a virtual 'car on water' possessing the same level of comfort, service, security, etc. Similarly, the potential shift from bus to waterway is obtained by taking the boat to have the characteristics existing in public transport system in the region, where the boat is assumed as a 'bus on water'. Since the modal shift is sensitive to the changes in speed, headway and fare of the boat service, a set of matrices are found to determine the extent of the modal share by varying the above.

3.3.2.1 Generalized Cost of Travel

The generalized cost of travel is the impedance for travel, and is expressed as follows for travel by bus and boat;

$$GC_i = F_T + T_T \times VOT + K \times WT_T \times VOT \qquad (3.1)$$

Where,

GC_i = Generalized cost of travel by Mode i,

F_T = Total Fare in Rs.

T_T = Total In Vehicle Time in hrs.

WT_T = Total Waiting Time in hrs.

VOT = Value of Time of users in Rs/hr

K = Constant for averaging the waiting time taken as 2.5 by Widanapathiranage and Kumarage (2003)

The total fare is expressed as;

$$F_T = F_b + \sum F_B \qquad (3.2)$$

Where,

F_B = Fare in Bus

F_b = Fare in Boat

Thus for bus travel only, F_b = 0.

Similarly the total in vehicle time is expressed in Equation 3.3;

$$T_T = T_B + \sum T_b \qquad (3.3)$$

Where,

T_B = In Vehicle time in Bus

T_b = In Vehicle Time in Boat

According to the study done on bus and rail demand model for the CMR by Widanapathiranage and Kumarage (2003), the waiting time for buses can be taken as;

$$WT = \frac{1}{2} \times h \qquad (3.4)$$

Where,

h = Headway

Thus if the same relationship is assumed for canal transport and an additional time penalty is accounted for a transfer, from one mode to another, the Equation 3.4 can be modified for total waiting time as follows;

$$WT = \frac{1}{2} \times \left(h_C + \sum_{i=1}^{n_B} h_{Bi} \right) + TT \qquad (3.5)$$

Where,

h_C = Frequency of Canal service

h_B = Frequency of Bus service

n_B = Total number of bus links used in travel.

TT = Transfer Time

The transfer time is expressed as;

$$TT = TT_{bus \to bus} + TT_{bus \leftrightarrow canal} \qquad (3.6)$$

where,

$TT_{bus \to bus}$ = Total transfer time for bus → bus transfers. (This transfer time is assumed at 3 minutes per transfer)

$TT_{bus \leftrightarrow canal}$ = Total transfer time for bus → canal & canal → bus transfers. (This transfer time is assumed at 5 minutes per transfer)

The transfer time accounted for the bus to canal and canal to bus is higher than the bus to bus transfer time, to account the additional walking time a canal user has to undertake to the arrive at a bus stop to continue the journey.

The Equation 3.1 can be re written for generalized cost of travel for car users as;

$$GC_c = D_T \times VOC + T_T \times VOT \tag{3.7}$$

Where,

GC_c = Generalized cost of travel by car.

D_T = Total travel distance

T_T = Total In Vehicle Time in hr.

VOT = Value of Time of all occupants in Rs/hr

VOC = Vehicle operating cost of car in Rs/km

3.3.2.2 Binary Logit Model

The most common form of modal split model used is called the Logit Model, which for 2 modes of transport between a nodal pair can be expressed as follows (Boile *et al*, 1994).

$$P_1 = \frac{e^{-\beta GC_1}}{e^{-\beta GC_1} + e^{-\beta GC_2}} \tag{3.8}$$

$$P_2 = 1 - P_1$$

where,

P_1 = The proportion of trips by mode 1

P_2 = The proportion of trips by mode 2

GC_1 = Generalized cost of travel by mode 1

GC_2 = Generalized cost of travel by mode 2

β = Mode independent parameter.

Thus according to the logit model if we assume that all the attributes between the two modes are same for the user, then theoretically the generalized cost is the same for both modes hence, the modal share is 50% for both modes. Subsequent changes in speed, headway and fare on boat service gives the corresponding increases or decreases in its share on boat, which is presented in Chapter 6.

3.3.3 Parameter For Financial Feasibility

In the absence of data on vehicle operating cost for boats to be used for the intended boat service, a guideline to achieve the feasible vehicle operating cost of boat ($VOC_{optimum}$) presented on which the assessment on financial feasibility can be made. The derivation of $VOC_{optimum}$ is presented below.

The revenue for the boat service depends on the fare and the demand for the service, thus it can be written as;

$$Revenue(R) = Fare\ (F) \times Demand\ (D) \tag{3.9}$$

The revenue increases with the increasing fare but at the expense of decreasing demand. Since demand for the boat service cannot be estimated at this stage, the modal share calculated for each origin and destination can be used to calculate the demand as given in equation 3.10 taking the total demand between a O-D pair as a link constant D.

$$D = TD \times P_{Boat} \tag{3.10}$$

Where,

TD = Total demand between two nodes

P_{Boat} = Modal share on Boat between the two nodes

The methodology of graphically obtaining the feasible operating cost of boat is illustrated in Fig. 3.1 where the $VOC_{optimum}$ can be found by the fare on which optimum revenue is obtained. Corresponding horizontal axis value is the fare on which the optimum revenue is achieved.

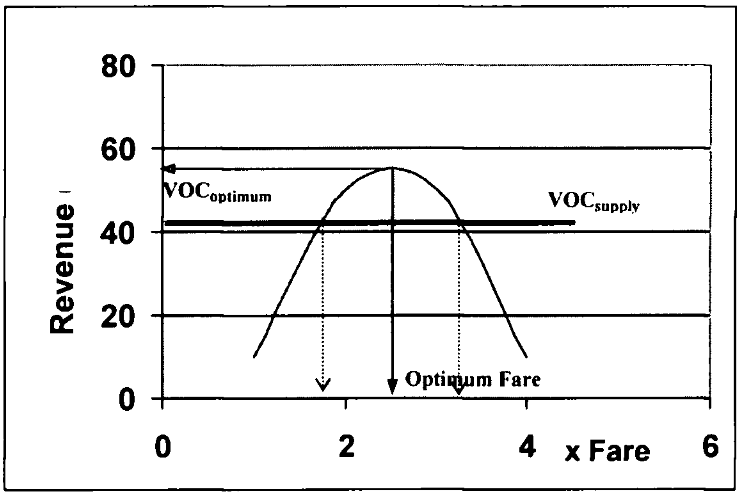

Fig. 3.1 Graph of Revenue Vs Fare

Thus if the boats can be operated at a lower value than the feasible operating cost as shown in equation 3.11 it can be presumed that the service be financially viable between that particular O-D pair.

$$VOC_{Supply} \leq VOC_{optimum} \tag{3.11}$$

where,

VOC_{Supply} = The actual vehicle operating Cost of boat

The actual vehicle operating cost is a straight line on the graph since it will be a constant value for a particular speed and frequency of the boat service. Thus as shown in Fig 3.1 when the actual vehicle operating cost is lower than the optimum value there will be a range for the fare on which a financially feasible service can be obtained. The above range will be greater when the actual vehicle operating cost reduces from the optimum value shown above.