CHAPTER — 1.

1.1 Introduction

1.2 Scope

1.3 Objectives

1.4 Methodology

1.5 Limitations of the present study

1.1 Introduction :-

The main objective of the public transport system is to transport various people, luggage etc., that are stored at various origins, to different destinations in such a way that the multiple objectives will be optimized.

Traditionally, the various optimization techniques used for a transportation system are based on a single objective criterion i.e. cost minimization or revenue maximization. Such problems are referred to as the problems of constrained optimisation.

Linear Programming is a technique for determining an optimum schedule of interdependent activities in view of the available resources. Basically, linear programming is a deterministic mathematical technique which involves the allocation of scarce or limited resources in an optimal manner on the basis of a given criterion of optimality.

In Linear Programming decisions are made under certainty, i.e. information on available resources and relationships between variables are known. Therefore actions chosen will invariably lead to optimal or nearly optimal results. It also helps in verifying the results arrived at by intuitive decision making and indicate the errors involved in the selection of optimal course of actions. In sum, one can say that Linear Programming provides a quantitative basis to assist a decision maker in the selection of the most effective and desira-

ble course of action from a given number of available alternatives to achive the result in an optimal manner.

For the two variable problems, the **Graphical Method** of Linear Programming can be applied for identifying all the corner points and to determine which corner point yields the optimum value for the objective function is quite simple. Whereas, in real world Linear Programming problems frequently involve more than two decision variables and also many constraints. Such problems, of course cannot be solved by graphical method. For these problems, mathematical iterative procedure known as **Simplex Method** is applied.

The main limitation of Linear Programming is that its objective function has to be unidimensinal. That is, it is assumed that the decision maker strives for a single objective, such as profit maximization or cost minimization. In many real cases, however multiple goals and sub-goals must be considered. Various goals may be expressed in different units of measurements. Some of them may be complementary and some may conflict with each other. In other words when decision maker has multiple incommensurable goals, ordinary Linear Programming incorporates only one of these goals in the objective function and treats the remaining goals as constraints. Since the optimal solution must fully satisfy all

constraints, this structuring of the problem implies that --

i) the several goals within the constraining equations are of equal importance to the decision maker and

ii) these goals have absolute priority over the goal incorporated into the objective function.

A second limitation of the Linear Programming is that the coefficients of the decision variables in the objective function must be assigned cardinal values (numbers that express exact amount such as 1, 2, 3 etc.). These cardinal values not only force decision maker to indicate the importance of each goal but also assign weights indicating how much one goal is valued over the other. When these goals are incommensurable (units of measurement are different), these goals cannot be assigned cardinal ranking.

These two short comings i.e. unidimensionality and commensurability can be overcome by using goal programming technique.

In most real life situations, the decision making process is characterised by multiple goals (objectives) rather than merely by a single objective. These multiple goals are generally complementary, conflicting as well as non-commensurable. In such a situation, only one of these objectives can be chosen for incorporating in the objective

function in a Linear Programming model while the remaining goals are taken as constraints. Thus, the goals in the constraints have absolute priority over goals in the objective function thereby making the goal selected in the objective function as the least important goal. The simplex algorithm would then select, from the set of all feasible solutions that satisfy all resources and goal constraints, a solution that optimizes the objective function. If no feasible solution exists the goal in the objective function (the least important goal) would be dropped and a new Linear Programming is formulated. The new formulation would then have the next least important goal (taken from the constraints) placed in the objective function. If the solution is again infeasible, one would continue to proceed in the same fashion until a fesible solution is reached. To overcome such difficulties, goal programming is used in place of linear programming in multiple objective situations. The fundamental notion of goal programming involves incorporating all managerial goals into the system model formulation. In goal programming, instead of maximizing or minimizing the objective function directly, the deviations among goals and the achievable limits dictated by the given set of resource constraints are minimized. These deviational variables which are called slack and surplus variables in Linear Programming acquire new meaning and significance in Goal Programming and are known as positive and negative deviational variables.

Goal programming is a more general technique than Linear Programming. It allows simultaneous solution of a system of complex multiple objectives rather than a simple objective. It is a technique that is capable of handling decision problems that deal with a single goal with multiple sub-goals as well as problems with multiple goals and multiple sub-goals.

Thus, for a public system, it is necessary to use the criteria to satisfy rather than to optimize. An optimizer selects the best possible alternative plans of action while a satisficer attempts to achieve a satisfactory level of multiple objectives. As most transportation problems involve multiple conflicting objectives, a Goal Programming technique applied to the problem of treating multiple objectives in multiple dimensions is most appropriate.

The Goal Programming can be used in any area of interest like ---

i) Production

ii) Planning

iii) Stock Control

iv) Reservation

v) Investment etc.

1.2 Scope :—

The scope of the study is to bring light on the application of Goal Programming technique to Public Transport System. The software package developed here provides better / optimal allocation of buses by which commutators get better service at a reasonable cost.

This study is computerised since the computer can run the iterations at high speed. It reduces the time required for the study and provides a solution in a quick way with more accuracy.

Even errors made in manual calculations in repeated simple mathematical calculations are also reduced, and even the clearity is maintained.

The software package can be used for any application like —

i) Production

ii) Planning

iii) Stock Control

iv) Reservation

v) Investment etc.

The results obtained will provide a base to distribute the total buses available with Kolhapur Municipal Transport in an optimal way to provide better service to the passengers at reasonable rates.

1.3 Objectives :-

The main objective of the present study is to Develope a Software Package for Goal Programming. This Software Package is then used to obtain the optimal distribution of buses to different routes run by Kolhapur Municipal Transport.

The other objectives of the present study are --

i) To redistribute the total number of available buses with Kolhapur Municipal Transport after collecting the data from Kolhapur Municipal Transport regarding total revenue earned, bus allocation, traffic density/occupancy and travel time etc.

ii) To reallocate the available number of buses to various destinations in terms of total revenue earned, traffic density/occupancy and travel time etc.

iii) Formulating the given problem in terms of Goal Programming with an objective of redistributing of total number of available buses to each route and maximisation of total revenue earned.

As Kolhapur Municipal Transport is service oriented organisation while formulating first priority has been given to occupancy so as to provide service to people. Second

priority has been given to Revenue so as to maximize revenue earned. And last priority has been given to total number of buses available with Kolhapur Municipal Transport, and has been put a condition either not to increase nor to decrease the total number of buses available i.e. niether to over utilize and nor to under utilize the total availability of buses.

1.4 Methodology :—

The methodology adopted for the present study is as follows --

First of all the public transportation system was studied by discussing it with the office staff of Kolhapur Municipal Transport and with the commuters.

After discussing thouroughly it is found that the public transport system has got multiple objectives with conflicting attitudes.

The various aspects which influence the overall operational efficiency of Transportation System considered here are --

i) Operational Cost per Bus per Km.

ii) Travel time (in minutes) per Bus per Km.

iii) Revenue per Bus per Km.

iv) Occupancy per Bus per Km.

v) Total Km. per Day

vi) Total Commuters.

Thus, an attempt has been made to optimize the overall efficiency of the system by optimizing each of the multiple goals simultaneously depending upon the priority ranking.

The over-riding emphasis in the optimization technique, thus should be on routing and scheduling of buses with a view to satisfying the maximum demand/requirement of commuters (users) out of the given fleet size only.

Public transport system

Users	Operators	Community
i) Maximum fulfilment of requirement.	i) Maximum revenue.	i) Optimum Utilization of its resources.
ii) At minimum cost.		

Thus, the goals under Public Transport System are --

i) Minimize the Operational cost.

ii) Minimize the Travel time.

iii) Maximize the Revenue.

iv) Maximize the Occupancy.

v) Allocate the number of buses (based on route length) to each sector.

Profile of Kolhapur Municipal Transport has been collected from office records and it has been found that there are six control points from where buses run to cover almost all areas within Kolhapur city.

The data regarding Passengers, Trips and Revenue earned per day per bus has been collected from Kolhapur Municipal Transport. And even information regarding the Routes covered from each Control Point, total Kilometer covered to run each destination from a Control Point and total Time required is collected from Kolhapur Municipal Transport.

The six Control Points are --

i) Bhawani Mandap
ii) Shivaji Putla
iii) Gangavesh
iv) Shahu Maidan
v) Maharana Pratap Chowk
vi) Sonya Maruti Chowk

It is observed that the route lengths for --

Bhawani Mandap and Shivaji Putla is 1 to 7 Kilometer,
Gangavesh and Shahu Maidan is 7 to 11 Kilometers and
Maharana Pratap Chowk &
Sonya Maruti Chowk is 11 to 18 Kilometers.

The data has been collected for each and every Control Point separately. Three equations are formulated for occupancy, revenue earned and total availablity of buses considering route lengths for two Control Points merged together.

1.5 Limitations Of The Present Study :—

Every study/ system has got its own limitations and advantages over any other system. This study even has got some limitations. The limitations are as follows --

i) While formulating the problem it has been assumed that the operational cost is constant/ same for every Control Point as the Control Point are very near to each other.

ii) The data for Occupancy is collected for a busy day and is assumed that the density of Occupancy remains same for all days. Whereas the density of passengers depends on various factors such as --

a) Festival
b) Weekly off
c) Public Holiday
d) Industrial off
e) Summer Vacation etc.

iii) In the present study, one may consider travel time of the buses and minimize it which in turn helps in running more number of trips.

iv) The present study only re-allocates or re-distributes the total number of buses available with Kolhapur Municipal Transport to various Control Points which gives better service to passengers and maximises the Revenue earned, but does not suggest how many trips each bus should be run.

v) The data for Double-Decker buses and Road train buses has been droped which even must be included in the study as Kolhapur Municipal Transport has Double-Decker as well as Road train buses.

vi) The total number of passengers travelled by bus is known but what distance they have travelled by bus is not known and thus it is assumed that every passenger has travelled from Control Point to the last end of the route.