Chapter I

INTRODUCTION

The increase in rice production with fluctuating rates, due to adoption of technological advancement, high yielding varieties, cropping pattern, irrigation facilities, fertilizer utilization, increase in area under rice cultivation, and Government's willingness to mechanize post harvest operations, has posed many new problems to the management groups of different agencies involved in rice processing and storage. One of these problems is to find the optimum number, size, and location of processing facilities subject to certain constraints in a defined region. Experience and intuition may not be the only means to tackle such problem. There are other ways to solve this problem by exploiting certain new disciplines of Science and Technology such as operations research or systems engineering which enables to analyse the problem systematically.

Irrespective of their categories, the industries to be located may be classified into two groups :

1. Unlimited plant capacity.
2. Limited plant capacity.

The unlimited plant capacity implies that there is no restriction on the volume of raw material to be allocated to the located plant. In other words, whatever capacity is obtained in solving the Location-Allocation problem (Cooper, 1963) is the capacity of the plant. Whereas in the case of limited plant capacity, the technology of plant restricts the volume of raw material to be allocated, and such a plant which involves a series of operations is balanced with certain efficiency.

This problem involves the determination of number, size, and location of plants under the capacity constraints in a defined region. Basically this problem involves minimizing the sum of assembly, pretreatment, and processing costs subject to capacity constraints. Assembly and processing costs are always incurred in locating any type of industry, whereas pretreatment cost may or may not; it depends on whether raw material to be processed requires any pretreatment. The defined region has many scattered points where raw material is available. The cost associated with transportation of raw material and assembling it to a few desired points is known as assembly cost, whereas the cost of processing of assembled material is termed as processing cost.

The minimum number of plants required depends upon their capacities and once this number is determined, the assembly cost, if possible, may further be reduced by increasing the number of plants. In doing so, the distances between the sources and plants are further reduced and hence any assembly cost function will reduce the cost. But, in achieving this reduction in assembly cost, there will be an increase in processing cost atleast equivalent to fixed cost of the plant. Hence, any decision on number of plants depends upon, whether the total combined cost increases or decreases.

A comprehensive study of the Location-Allocation problem for unlimited plant capacity case has been done by several research workers and a substantial amount of literature describing the algorithms invented by them on this topic is cited in the next chapter. Except Cooper (1967, 1972), who located a predetermined number of plants under capacity constraints considering assembly cost only by adapting 'transportation-problem' technique, all other workers have analysed the unlimited plant capacity problems. Hence, there seems to be a wide scope to study the limited plant capacity problem which may help solve many Location-Allocation problems under capacity constraints.

Statement of the Problem

The intent of this research is to provide a mathematical model for locating the plants which have limited capacities. This problem, as described in the preceding section, is exceedingly difficult and may not as such be solved without making some simplifications. These simplifications are based on certain features of the models formulated by different research workers. Firstly, Cooper (1963) rightly advocated that the objective function to be minimized is continuous and thus it guarantees that the location may be at any point in the region under consideration in contrast to Stollsteimer's (1963) model which limits the plant locations upto the sources only. Secondly, Kuehn and Hamburger (1963) obtained suboptimal solution by using non-convex unit assembly cost functions for long distance hauling. Finally, Goldstone's (1968) suggestion, to use third or fourth or even fifth power weighting to obtain the starting value of plant location very close to true location, is worth to adopt. Hence, the simplifications with respect to this study have been made :

1. By devising some techniques which provide suboptimal results with very less error and thus reducing the computation time.

2. By using the features of the unlimited plant capacity models enumerated earlier in this section.

Now the problem to be formulated may be stated very briefly as : Given a defined region with some scattered production points and their weights, some form of assembly cost function, pre-treatment and processing cost functions and their capacities; find the optimum/suboptimum number, size, and location of plants under capacity constraints in the region.

This formulation includes the features from both the unlimited and limited plant capacity problems and it provides one of the most general formulations of the Location-Allocation problem. The special case of unlimited plant capacity problem is obtained from the general formulation by deleting capacity constraints.

Capacity Constraints

Regardless of the categories of industries involved, each one has different capacities which are designated as types of plant. Due to technological feasibility these types are limited in number. In locating the plants and subsequently allocating the sources though there may be some sources close to one particular plant, but once the amount of raw material allocated to it reached the plant capacity, then these are allocated to the next nearest plant. This restriction imposed on plant capacity is known as capacity constraint. Each type of plant has its own constraint. But the number of constraints equals the number of plants.

These capacity constraints will give enough variability in Location-Allocation problem, and this is the major cause why unlimited plant capacity problems are quite different from the limited one.

Objectives

The objectives of this study are :

1. To formulate a general mathematical model of the problem and derive various simplifications of the general model.
2. To devise and test the algorithms and select the best one for solving the various simplifications of the general model.
3. Applications of models for locating the rice processing plants.
4. To extend the models for locating the by-product utilization plants, and to suggest the use of non-convex unit assembly cost functions for plant location.