CHAPTER – I

INTRODUCTION

1.1 Introduction

Agriculture is one of the important economic sectors. After independence of our country, agricultural production has been brought about by bringing additional area under cultivation, extension of irrigation facilities, use of better seeds and modern techniques, water management and plant protection. The agriculture sector contributes only about 18 per cent of the total GDP, with more than 58 per cent population dependence, resulting in low per capita income in the farm sector (Anonymous, 2007). Consequently, there is a large disparity between the per capita income in the farm sector and the non-farm sector. Therefore, it is essential to deal with those issues which impact the income levels of farmers. Today India has attained self sufficiency in food grains sector. The per capita availability of a number of food items in India has increased significantly in the post-independence period despite of increase in agriculture.

The topography of India, soil types, rainfall availability of water for irrigation are the factors that determine the crops and livestock pattern. Agriculture in India can be divided into three major regions the Himalayas, the Indo-Gangetic Plain and the Peninsula—and their agro-ecological sub regions. The monsoons play a critical role in determining whether the harvest will be bountiful, average or poor in any given year. The dependence of Indian Agriculture to the vagaries of the south – west monsoon and hence the value of irrigation were well recognized since time immemorial. After independence, India made great strides in irrigation development. As such India has now one of the largest irrigation networks. However, in spite of the phenomenal growth of irrigation potential, the agriculture production from irrigated area is not commensurate with the associate large investment in the irrigation sector. Efficiency in the use of irrigation water leaves much to be desired. Lack of
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A scientific approach to water management has lead to undesirable effects on irrigated areas, such as water logging, build up of soil salinity and ground water management. There is an immense need and scope for improving the efficiency of irrigation water management through judicious use of surface and ground water.

India today is facing a critical situation in relation to land - use planning. Even though the food grain production recorded almost a fourfold increase in the post-independence decades, shortage of rice, pulses and oilseeds is growing. Shortages of pasturelands, firewood and fast depletion of the forest wealth are assuming serious proportions. As a consequence of various development endeavors ecological imbalances e.g. soil erosion, rapid situation of dams, shortage of ground water, land and water pollution, water logging etc. are growing adversely affecting the agricultural productivity. Unless special efforts are made towards preservation of the land, water and vegetative resources of the country and its long term sustainable use is planned, the food grains and other basic needs of the country's population cannot be met, food security and self-reliance cannot be assured and enhanced livelihood security to the oiling millions in India cannot be ensured.

Agricultural development is a complex process of interaction between the physical input - output relations of the agricultural system and the social and economic milieu of the national economy in a dynamic equilibrium. Land use planning and irrigation are strategic planning exercise to assess the future potential of the agricultural sector and achieve accelerated growth through judicious management of land and water resources.

1.2 Present Scenario

The food, nutritional, livelihood and economic security of our country continues to be predicated upon the agriculture sector and the situation is not likely to change in the near future. Even now, nearly 72 per cent of our population lives in rural areas and about 58 per cent are engaged in
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agriculture (Rai, 2006). But there is evidence to indicate that the land sector cannot bear the burden of growing population, not withstanding the untapped potentials for agricultural productivity growth in many regions. Therefore, there is a felt need for both horizontal and vertical diversification of the agricultural economy. This is particularly so because all lands and locations are not equally suitable for profitable, alternative farming and hence, there is need for cluster approach to development.

As of today, India supports 16.8 per cent of the world’s human and 11 per cent of the livestock population on 4.2 per cent of the world’s water resources and 2.3 per cent of the global land. The contribution of agriculture and allied sector to the GDP has fallen from 61 to 18 per cent in the last 50 years. Per capita availability of resources is about 4 to 6 times less as compared to the world average (Rai, 2006). Foreseeably, this will further decrease due to increasing demographic pressure and consequent land diversion for non-agricultural use if by matching improvement, eroded and degraded land are not additionally brought to cultivation.

The area under food grain cultivation was 97.32 mha (year 1950-51) of which only 18 per cent was irrigated, and the productivity stood at 522 kg/ha and production around 51 mt. Population at that point of time was 361.1 million and growing at a modest rate of 1.25 per cent the population by 1961 touched 439.2 million at a growth rate of 1.96 per cent, whereas to food grain production increased to about 82 mt and the gap in the requirements had to be bridged through food grain imports (Rai, 2006). Simultaneously, intensive efforts were made to strengthen agricultural research and education in the country and positive results ushered in Green Revolution. Thus, ended an era of food grain imports and the stigma of ‘begging bowl’ and ‘ship to mouth’ status was permanently shed off.

As per the projections, our population will be 1.5 billion (of the world population of 11 billion) by 2050. Rising population and per capita income are pushing up the demand, which needs to be met through enhanced
productivity per unit area, input and time, the annual increase in demand in India is estimated to be 2.6 mt in rice, 2.2 mt in wheat, 1.6 mt in pulses, 4.2 mt in fruits and 2.5 mt in vegetables. Presently, it requires to accelerate the growth rate of agricultural production from present level of about 3.70 per cent to about 6.80 per cent to fulfill the food demand of fast growing human population of the country (Rai, 2006).

1.3 Major Constraint in Agriculture

The water is a critical and major constraint on raising agricultural productivity and much of the success of the Green Revolution came from improved productivity in areas of assured irrigation provided through canals or through ground water utilization. The scope for expanding irrigation through large and medium scale projects has yet to be fully exploited. Out of the total of 59 mha that could be irrigated through such projects only 40 mha have been irrigated (Ahluwalia, 2005).

Due to less charge of irrigation water, effective maintenance of the existing system of canal irrigation also suffers covering only 20-25 per cent of the operations and maintenance cost of the system in most states. Poor maintenance leads to loss of water through seepage, with the result that water use efficiency is very low – around 25 to 40 per cent instead of 65 per cent that should be attainable (Ahluwalia, 2005). Low water charges also encourage highly water intensive crops at the upper end of the canal network, leaving tail-end portions starved of water. Ground water utilization played a major role in expanding irrigation in the year 1980, but uncontrolled exploitation of groundwater has led to serious depletion of the water table in many parts of the country. They are also distributionally unfair because the benefits of under priced water accrue disproportionately to upper end farmers whereas under priced power enables those able to afford larger pumps to lower the water table denying water to farmers who can only afford shallow wells.
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Out of India’s total cultivable area, about 60 per cent of area will remain dependent on dry land farming even after all irrigation potential is fully exploited. Productivity growth in these areas is obviously critical for rural income growth and poverty alleviation, and it depends critically upon better moisture conservation and the development of varieties suited to dealing with moisture stress. Further, rain fed dry lands constitutes 65 per cent of the total net sown area. Also there is an unprecedented degradation of land (107 m ha) and groundwater resource. Currently only 29 per cent of the total precipitation is conserved, that too not optimally utilized. With the existing practices, water use efficiency seldom exceeds 40 per cent (Ahluwalia, 2005).

It is a common experience that in almost all the irrigation command areas, the ground water table rises causing the problems of water logging, soil salinity, destruction of soil texture, decline in fertility and yield, eventual abandoning of the land. The available supply in the most of the canal systems for instance is often only one fourth to one third of the amount needed for intensive agriculture. The total quantity of irrigation water is neither adequate nor is supplied satisfactorily in time. Under such conditions integrated planning of surface and ground water has an immense potential for augmenting available water supplies. The present research efforts are directed towards this end.

In a developing country like India, land is not only an important factor of production, but also the basic means of subsistence for majority of the people. As with water, the land resource has also been mismanaged in the current era. The country is governing over the total geographical area as 328 mha but the net area sown is 142.15 mha with the gross cropped area as 180.00 mha while net irrigated area is 43.05 mha with 55.64 mha as gross irrigated area (Sahay, 2006).

Thus, the efficient use of land, water and other natural resources are major thrust areas to be established for accelerated as well as sustainable
economic development of agriculture. For this, the farm management is the important parameter in order to optimize the agricultural activities.

1.4 Farm Management

Farm management deals with the organization and operations of a farm with the objective of maximizing profits from the farm business on a continuing basis. Farm management is the emphasis on the decision-making function of evaluating and choosing between alternative strategies. A major concern is about adjustments which are more suitable and profitable and about exploring new situations and opportunities for maximization of income and satisfying other goals of agriculture. It is the approach under which the opportunity costs of the various resources are evaluated and adjustments in resource-use and enterprise mix are made to secure higher levels of farm income. It normally pertains to the existing pattern of the resource-use and crops-mix under which only the existing plan is executed.

Thus farm management is the science which deals with the analysis of the farming resources, alternatives, choices and opportunities within the framework of resource restrictions and social as well as personal constraints of farming business. This complex information is integrated and synthesized to increase profitability of the farming business, the ultimate aim being to raise the standard of living of the farming people. This does not mean that farm management deals exclusively with the maximization of income; in fact, it takes into account the goals and objectives of the individual, other than income maximization. Thus this discipline deals with people or organizers and decision-makers in respect of farms and agricultural production. Here we are not just concerned with the distribution of labor and irrigation water for day-to-day operations.

Basically farm management is economics in the context of fundamental definition of economics which involves three elements, viz. the scarcity of resources, their alternative uses and the objective of profit maximization. It is
this science which deals with making rational, profitable and economic recommendations to the farmers. It also deals with the growth and stability aspects of economics.

The basic information about the multiple (alternative)uses to which the scarce resources can be allocated is supplied by other physical and biological sciences. The research in these sciences should continually generate the relevant data on alternative technologies and practices whose profitability can be tested under actual farm situations and these data are required for the farm organization as a whole and not far for a single hectare.

Agricultural scientists mainly put emphasis on the maximization of yield rather than on the use of the optimum level of resources. But the goal in farming is not to make a profit on some single enterprise or from a part of the farm land, but to use land, labor and capital resources in such a way that they make the greatest contribution to the total profits from the entire farm. The superiority of this discipline, thus, lies in its treating the farm as an operational unit and tailoring the recommendations of all other disciplines to fit into an individual area's pattern of resources.

In the context of the recent technological breakthrough, management today should be viewed as a process within a rapidly moving frame of reference. "It is now more scientific, less artistic; more dynamic, less static; more versatile and less rigid". Farm management is forward-looking in its approach. Its task is not so much the improvement of the present farming practices but of the establishment of the whole sets of new production methods and farming systems which would put our agriculture on a continuously rising growth curve.

Farm management is a decision-making science. It helps to decide about the basic course of action of the farming business. The basic decisions of the farming business are:

(a) What to produce or what combination of different crops to follow?
(b) How much to produce and what is the most profitable level of production?

(c) What methods of production (production practices or what type of quality of inputs and their combination) should be used?

(d) What and where to market?

The complexity of farming system and the uncertainty associated with the decision making process are features which indicate that system approach to research could be particularly useful. There seems to be growing recognition of the need for approach of Operations research to the farm management.

1.5 Operations Research

As per the defined by Churchman, Ackoff and Arnoff, “Operations Research is the most general sense can be characterized with the application of scientific methods, techniques and tools to problems involving operation of a system so as to provide those in control of the system with optimum solutions to the problem”.

The subject of O.R. originated during World War II, when the British and American military management called upon a group of scientists to study and plan the war activities, so that maximum damages could be inflicted on the enemy camps at minimum cost and loss. Because of the success in military operations, it quickly spread in all phases of industry and government organizations. The Russian mathematician L. Kantorovich has, for a number of years, been interested in the applications of mathematics to programming problems. In 1941, F. L. Hitchcock formulated and solved the transportation problem. In 1947, T. C. Koopmans solved the transportation problem. The minimum cost diet problem was studied by economist Stigler in 1945. In 1947, G. B. Dantzig suggested an efficient method known as the simplex method, which is an iterative procedure to solve any linear programming problem in a finite number of steps.
In India, it came into existence in 1949, with the opening of an operations research unit at the Regional Research Laboratory at Hyderabad. In June 1951, the first symposium in linear programming was held in Washington. Kantorovich and Koopmans were awarded the Nobel Prize in the year 1975 in economics for their pioneering work in linear programming (Kothari, 1982). A lot of research work is being carried out all over the world.

The detailed study of the O.R. generally involves three phases viz., judgment phase, research phase and action phase. The basic pattern of the application of O.R. to a problem generally involves the following steps (Kothari, 1982):

1) Formulating the problem
2) Constructing the model
3) Deriving the solution
4) Testing the validity
5) Controlling the solution
6) Implementing the results

1.5.1 Classification of problems in O.R.

It can be put into one of the following categories viz.

1) Allocation
2) Replacement
3) Sequencing
4) Routing
5) Inventory
6) Queuing
7) Competitive
8) Search
1.5.2 Operational Research Techniques

Mathematical models have been constructed for the above categorized O.R. problems and methods for the solving the models are available in many cases termed as O.R. techniques. Some of the important O.R. techniques often used by decision makers in modern times in business and industry are as under (Kothari, 1982).

i. Linear Programming
ii. Waiting line or Queuing theory
iii. Inventory control / Planning
iv. Game theory
v. Decision theory
vi. Network analysis
vii. Simulation
viii. Integrated production models
ix. Some other O.R. techniques
   a. Non linear programming
   b. Dynamic programming
   c. Heuristic programming
   d. Integer programming
   e. Algorithmic programming
   f. Quadratic programming
   g. Parametric programming
   h. Probabilistic programming
   i. Search theory
   j. Theory of replacement

1.5.3 Linear Programming

In the competitive world of business and industry, the decision maker wants to utilize his limited resources in a best possible manner. The limited resources may include material, money, time, manpower, machine capacity
etc. Linear programming can be viewed as a scientific approach that has evolved as an aid to a decision maker in business, industrial, agricultural, hospital, government and military organizations.

1.5.4 Areas of Applications of LP Problems

Some important areas of applications of LP Problems are as under (Sharma, 2006).

1) Manufacturing problems

In these problems, we determine the number of units of different products which should be produced and sold by a firm when each product requires a fixed manpower, machine hours, labor hour per unit of the product, warehouse, space per unit of the output etc. in order to make maximum profit.

2) Diet problems

In these problems, we determine the amount of different kinds of constituents/nutrients which should be included in a diet so as to minimize the cost of desired diet such that it contains a certain minimum amount of each constituent / nutrient.

3) Investment problems

In these problems, we determine the amount which should be invested in a number of fixed income securities to maximize the return on investment.

4) Transportation problems

In these problems, we determine a transportation schedule in order to find the cheapest way of transporting a product from plants or factories situated at different locations to different markets.
5) **Blending problems**

In these problems, we have to determine optimum amount of several constituents to be used in producing a set of products while determining the optimum quantity of each product to be produced.

6) **Advertising media selection problems**

In these problems, we find the optimum allocation of advertisements in different media in order to maximize the total effective audience/customers.

**1.5.5 Concepts of LP Problems**

The term ‘programming’ means planning and refers to a process of determining a particular program. The term ‘linear’ means that all relationships involved in a particular program which can be solved by this method are linear. To make understandable the terminology of LP, it is necessary to give the mathematical model of a general LPP (Sharma, 2006).

Mathematically, the general LPP may be stated as,

Maximize or Minimize \( Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n \) \hspace{1cm} ...(1.1)

Subject to

\[ a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n (\leq, =, \geq) b_1 \]
\[ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n (\leq, =, \geq) b_2 \]
\[ \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \]
\[ a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n (\leq, =, \geq) b_m \]
\[ x_1, x_2, \ldots, x_n \geq 0 \] \hspace{1cm} ...(1.2)

Where

(i) the linear function \( Z \) which is to be maximized or minimized is the objective function of the LPP

(ii) \( x_1, x_2, \ldots, x_n \) are the decision variables

(iii) the equations/inequations (1.2) are the constraints of LPP
(iv) in the set of constraints the expression (≤,=,≥) means that each constraint may take any one of the three signs

(v) the set of equations (1.3) is the set of non-negative restrictions of the general linear programming problem

(vi) \( c_j \ (j = 1, 2, \ldots, n) \) represents per unit profit or cost to the \( j \)th variable

(vii) \( b_i \ (i = 1, 2, \ldots, m) \) is the requirement or availability of the \( i \)th constraint

(viii) \( a_{ij} \ (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n) \) is referred to as the technological coefficient.

1.5.6 Some definitions and concepts related to LP

1) Solution

A set of values of decision variables satisfying all the constraints of a linear programming problem is called a solution to that problem.

2) Feasible solution

Any solution which also satisfies the non-negativity restrictions of the problem is called a feasible solution.

3) Optimal feasible solution

Any feasible solution which maximizes or minimizes the objective function is called an optimal feasible solution.

4) Optimization techniques

The processes of obtaining the optimal values are called optimization techniques.
5) Feasible region

The common region determined by all the constraints and non-negativity restriction of an LPP is called a *feasible region*.

6) Convex region

A region is said to be convex, if the line segment joining any two arbitrary points of the region lies entirely within the region. Feasible region of an LPP is always a convex region.

1.5.7 Mathematical Formulation of a LP Problem

There are mainly four steps in the mathematical formulation of linear programming problem as a mathematical model. We will discuss formulation of those problems which involve only two variables.

1. Identify the decision variables and assign symbols $x$ and $y$ to them. These decision variables are those quantities whose values we wish to determine.

2. Identify the set of constraints and express them as linear equations/inequations in terms of the decision variables. These constraints are the given conditions.

3. Identify the objective function and express it as a linear function of decision variables. It might take the form of maximizing profit or production or minimizing cost.

4. Add the non-negativity restrictions on the decision variables, as in the physical problems, negative values of decision variables have no valid interpretation.
1.5.8 Advantages of LP Problems

We have seen that linear programming is extensively used in almost all areas of human life. It is used to minimize the cost of production for maximum output. In marketing, it involves selection of product, selection of advertising media. In finance department, it tries to optimize the return on the investment of capital and personnel department can appoint people of optimum skill at minimum cost in a very systematic manner. In transportation problems, linear programming techniques help in making transportation policy to reduce the cost and time of transshipment. In short, with the help of linear programming models, a decision maker can most efficiently and effectively employ his production factor and limited resources to get maximum profit at minimum cost. He can also take quick decisions which are important in modern times because any delay or postponement in it may give advantage to other organizations.

1.5.9 Limitations of LP

1. The linear programming can be applied only when the objective function and all the constraints can be expressed in terms of linear equations/inequations. In the real world situations, the objective function and all the constraints cannot always be expressed in linear form.

2. Linear programming techniques provide solutions only when all the elements related to a problem can be quantified. These models don't take into account the qualitative factors like human relations, behavior etc. which are equally important.

3. The coefficients in the objective function and in the constraints must be known with certainty and should remain unchanged during the period of study. But in day to day life, the price of a product varies according to the demand and supply of the product.
4. Linear programming techniques may give fractional valued answer which is not desirable in some problems. For example, a model for a production problem may advise to produce 1/2 car or 3/4 chair.

1.6 Objectives

Looking to the present scenario of Indian agriculture, Farm management involves large number of parameters viz. water resources, cost of cultivation, climatic conditions, suitability of soil for different crops, food requirement and food habits, marketing facilities and fluctuation of market price. It is difficult to arrive at a decision without the help of any programming approach. Therefore, it is of prime need to conduct the present research work on “Some Contribution of Operations Research in Profitable Farm Management”. The specific objectives of the present effort are:

1. To develop a mathematical model for cropping pattern for achieving maximum benefit
2. To evaluate a suitable cropping pattern for optimum utilization of available resources