Production Economics & Farm Management

Production Economics & Farm Management

ICAR e-Course
For
B.Sc (Agriculture) and B.Tech (Agriculture)

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1. INTRODUCTION TO FARM MANAGEMENT

Farm business management has assumed greater importance not only in developed and commercial agriculture all round the world but also in developing and subsistence type of agriculture. A farm manager must not only understand different methods of agricultural production, but also he must be concerned with their costs and returns. He must know how to allocate scarce productive resources on the farm business to meet his goals and at the same time react to economic forces that arise from both within and outside the farm.

The need for managing an individual farm arises due to the following reasons:

i) Farmers have the twin objectives, viz., maximization of farm profit and improvement of standard of living of their families.

ii) The means available to achieve the objectives, i.e., the factors of production, are scarce in supply.

iii) The farm profit is influenced by biological, technological, social, economic, political and institutional factors.

iv) The resources or factors of production can be put to alternative uses.

Farm management is concerned with resource allocation. On one hand, a farmer has a set of farm resources such as land, labour, farm buildings, working capital, farm equipments, etc. that are relatively scarce. On the other hand, the farmer has a set of goals or objectives to achieve may be maximum family satisfaction through increasing net farm income and employment generation. In between these two ends, the farmer himself is with a specific degree of ability and awareness. This gap is bridged by taking a series of rational decisions in respect of farm resources having alternative uses and opportunities.

The study of farm management would be useful to impart knowledge and skill for optimizing the resource use and maximizing the profit. The following definitions would throw light on the meaning of farm management:

A. DEFINITIONS

Farm means a piece of land where crop and livestock enterprises are taken up under a common management and has specific boundaries. All farm management economists can be categorized into three groups on the basis of whether they consider farm management as an art, science or business.

The first group of farm management economists comprising of Andrew Boss, H.C.Taylor and L.C. Gray viewed farm management as “an art of organization and operation of the farm successfully as measured by the test of profitableness".

The second group comprising of G.F. Warner and J.N. Effersen considered farm management "as a science of organization and operation of the farm enterprises for the purpose of securing the maximum profit on a continuous basis".

The third group of economists like L.A. Moorehouse and W.J. Spillman defined farm management "as a study of the business phase of farming".

The most acceptable definition of farm management is given below:

Farm Management is a science that deals with the organization and operation of a farm as a firm from the point of view of continuous maximum profit consistent with the family welfare of the farmer. Thus, in an environment where a farmer desires to achieve objectives like profit maximization and improvement of family standard of living with a limited stock of factors of production which can be put to alternative uses, farm management in an essential tool.

B. FARM MANAGEMENT DECISIONS

Farmers must be able to take appropriate decisions at appropriate time. Incorrect judgement and decisions would result in the failure of execution of farm plan and in turn economic loss. The farm management decisions can be broadly categorized into two ways.

i) The first method of classifications is according to the following criteria: a) Importance, b) Frequency, c) Imminence, d) Revocability and e) Alternatives available. Each of the above criteria is discussed briefly.

a) Importance: Farm management decisions vary as to the degree of importance measured generally through the magnitude of profit or loss involved. For example, a decision to engage in poultry is relatively more important than a decision regarding the type and location of poultry shed.

b) Frequency: Many decisions assume importance on the farm because of their high frequency and repetitive nature. The decision about what and how much to feed to the dairy animals is made more frequently than that regarding the method or time of harvesting of paddy.

c) Imminence: It refers to the penalty or cost of waiting with respect to different decisions on the farm. Experience shows that while it pays to act quite promptly in some cases, postponement is necessary in other cases till the required complete information becomes available. For example, the decision to harvest paddy is much more imminent than a decision about buying a tractor.

d) Revocability: Some decisions can be altered at a much lower cost as compared to others. For example, it is relatively easier to replace paddy with groundnut, which perhaps becomes more profitable, than to convert a mango orchard into a sugarcane plantation.

e) Alternatives available: The number of alternatives can also be used for classifying farm management decisions. The decisions become more complicated as the number of alternatives increase. For example, threshing of paddy can be done manually or with thresher.

Classification of decisions based on the above criteria is not mutually exclusive and is changing from individual to individual and from place to place for the same individual.

ii) The second method classifies farm management decisions into: a) what to produce? b) when to produce? c) how much to produce? and d) how to produce?

The farm manager should choose the enterprises based on availability of resources on the farms and expected profitability of the enterprise. This is studied through product-product relationship. Once the farmer decides on what to produce, he must also decide on when to produce, as most of the agricultural commodities are season bound in nature. Then, he should decide how much of each enterprise to produce, since the supply of agricultural inputs is limited. This can be studied through factor-product relationship. In order to minimize the cost of production, i.e., decisions relating to how to produce, factor-factor relationship has to be studied. The farm manager should also take marketing decisions like a) what to buy? b) when to buy? c) how much to buy? d) how to buy? e) what to sell? f) when to sell? g) how much to sell? and h) how to sell?

iii) Factors Influencing Farm Management Decisions: Farm management decisions continuously undergo a change overtime because of the changing environment around the farm, farmer and his family. The factors which influence the decision making process are:

a) Economic factors like prices of factors and products.
b) Biological characteristics of plants and animals.
c) Technological factors like technological advancements in the field of agriculture and suitability of different varieties and farm practices to varied agro - climatic conditions.
d) Institutional factors like availability of infrastructural facilities which include storage, processing, grading, transport, marketing of inputs and outputs, etc, government policies on farm practices, input subsides, taxes, export and import, marketing, procurement of produces and so on.
e) Personal factors like customs, attitude, awareness, personal capabilities and so on.

One or more changes of the above categories in the environment around the farmer may cause imperfections in decision-making. The process of decision making, therefore, has to be dynamic so as to adjust in such changes.

iv) Decision Making Process

Every farmer has to make decisions about his farm organization and operation from time to time. Decisions on the farms are often made by the following three methods:

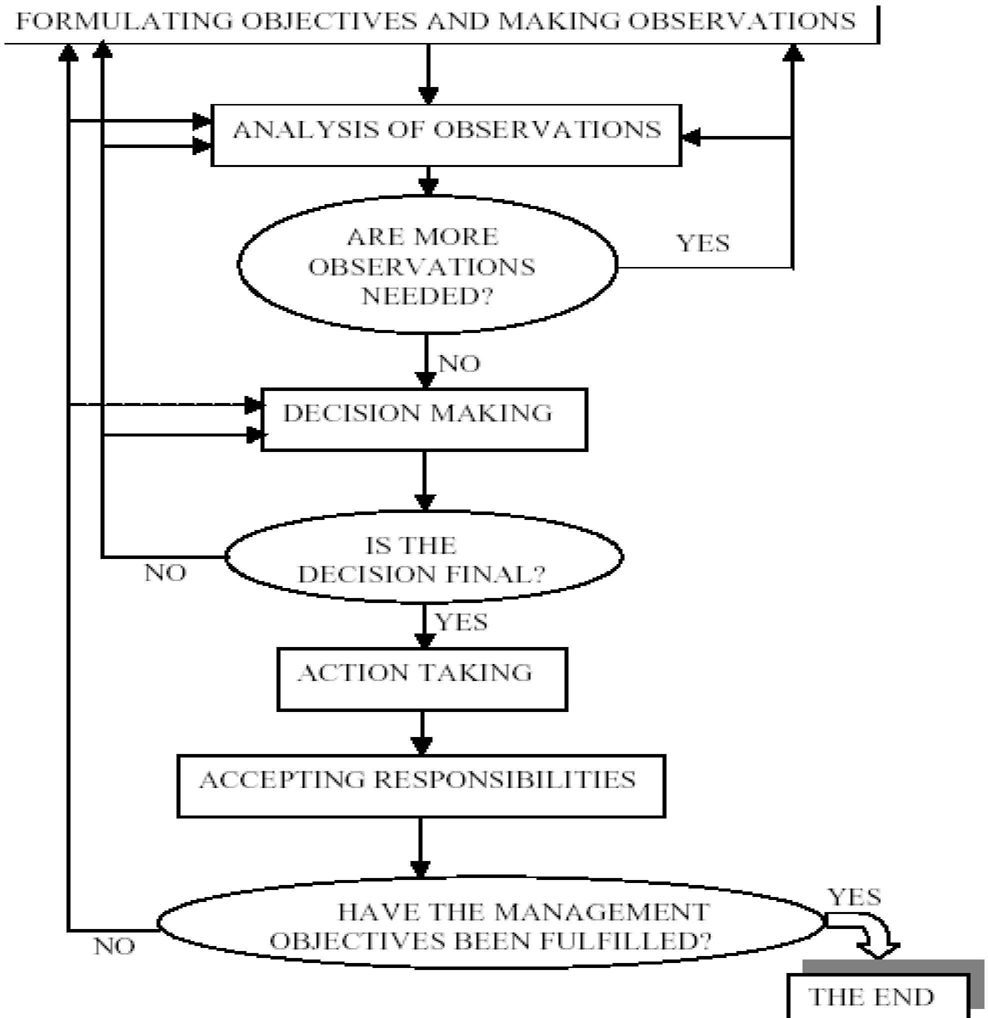
a) Traditional method: In this method, the decision is influenced by traditions in the family or region or community.

b) Technical method: In this method, the decisions require the use of technical knowledge. For example, a decision is to be made about the quantity of nitrogen requirement to obtain maximum yield of paddy.

c) Economic method: All the problems are considered in relation to the expected costs and returns. This method is undoubtedly the most useful of all the methods for taking a decision on a farm.

v) Steps in Decision Making

The steps in decision - making can also be shown schematically through a flow chart. The important steps involved in the decision-making process are formulating objectives and making observations, analyses of observations, decision-making, action taking or execution of the decisions and accepting the responsibilities. The evaluation and monitoring should be done at each and every stage of the decision making process.



Steps In Decision Making Process

vi) Functions of a Farm Manager: Some of the major areas, which form the subject matter of farm management, are listed below:

a) Farm Management Functions: The major farm management functions are:

1) Selection of enterprises.

2) Organization of agricultural resources and farm enterprises so as to make a complete farm unit.

3) Determination of the most efficient method of production for each selected enterprises.

4) Management of capital and financing the farm business.

5) Maintenance of farm records and accounts and determination of various efficiency parameters.

6) Efficient marketing of farm products and purchasing of input supplies.

7) Adjustments against time and uncertainty elements on farm production and purchasing of input supplies.

8) Evaluation of agricultural policies of the government.

b) Farm management activities are differently viewed by different authors. Farm managers are generally responsible for taking up technical, commercial, financial and accounting activities. These activities are elaborately discussed below:

Farm Management Functions

Activities	Functions	Details
1) Technical Activities: These include responsibilities for seeking all production know-how so that production is accomplished in time and adapting production process to changing economic and technical conditions.	Deciding what to produce? and how to produce?	Enterprise-choice and combinations. Input levels and combinations. Quality of output.
	Using Land	Capacity –fertility. Tillage practices conservation. > Regulations-constraints.
	Determining Level of Mechanization	> Capital requirements. > Availability of services. > Labour implications.
	Determining the scale of production (How much to produce?)	> Economics in production on buying. > Shape of cost curves. > Degrees of specialization. ¾ Quantity of output. Capabilities of management.

Activities	Functions	Details
2.Commercial Activities: These include all buying and selling. They involve procurement of inputs in the quantities and combinations	Acquiring inputs	> What to buy? -Type, Quality. > How to buy-own? Rent/lease, hire. > Financing. > From whom? > When/How long? > How much to buy? -Quantity.

necessary for efficient production, plus orderly storage, handling and marketing of commodities produced. It also includes forecasting and contracting for services of others.	Marketing products	> What to sell? -Quality/type > When to sell? -Store/immediate sales. > Where to sell? -Direct to buyer or store, delivery point, integration. > How to sell? –Open market, contract, hedge. > How much to sell? -Quantity
	Forecasting price	> Inputs. > Products.
3.Financial Activities: These involve the acquisition and use of capital, presumably in an optimal manner. This requires forecasting future investment needs and arranging for their financing.	Acquiring funds	> Quantity and terms of borrowing. Sources. Lender services. > Equity position. > Liquidity position.
	Using funds	> Relative profitability of alternatives. > Time horizon and pay-back period. > Cash flows.
	Forecasting future needs.	> Depreciation of assets. > Expansion / contraction. > Changing technology.
4.Accounting Activities: These include physical, human, business and tax records. This area may involve setting standards for certain enterprises or segments of the business.	Keeping production records	> Enterprise ownership. > Input-output efficiency.
	Recording business transactions	> Accounting method. > Choice of accounts. > Periodic summery. Cash flow forecasting.
	Tax reporting. Filing documents with Governmental and Regulatory Agencies.	> Income tax and other taxes. > Wages. > Social security. > Depreciation.

Lecture No. 2.

Farm management decision making process ? Production, operational, strategic, administrative and marketing management decisions.

c) The third classification of farm management functions indicates that the farm management decisions or functions can be categorized into production, administration and marketing functions as depicted in the chart.

1) Production and Organization Decisions: The farm manager has to take vital decisions on production of enterprises and organization of his business. His decisions centre on what to produce and how to produce. Such decisions can be further classified into i) strategic and ii) operational decisions.

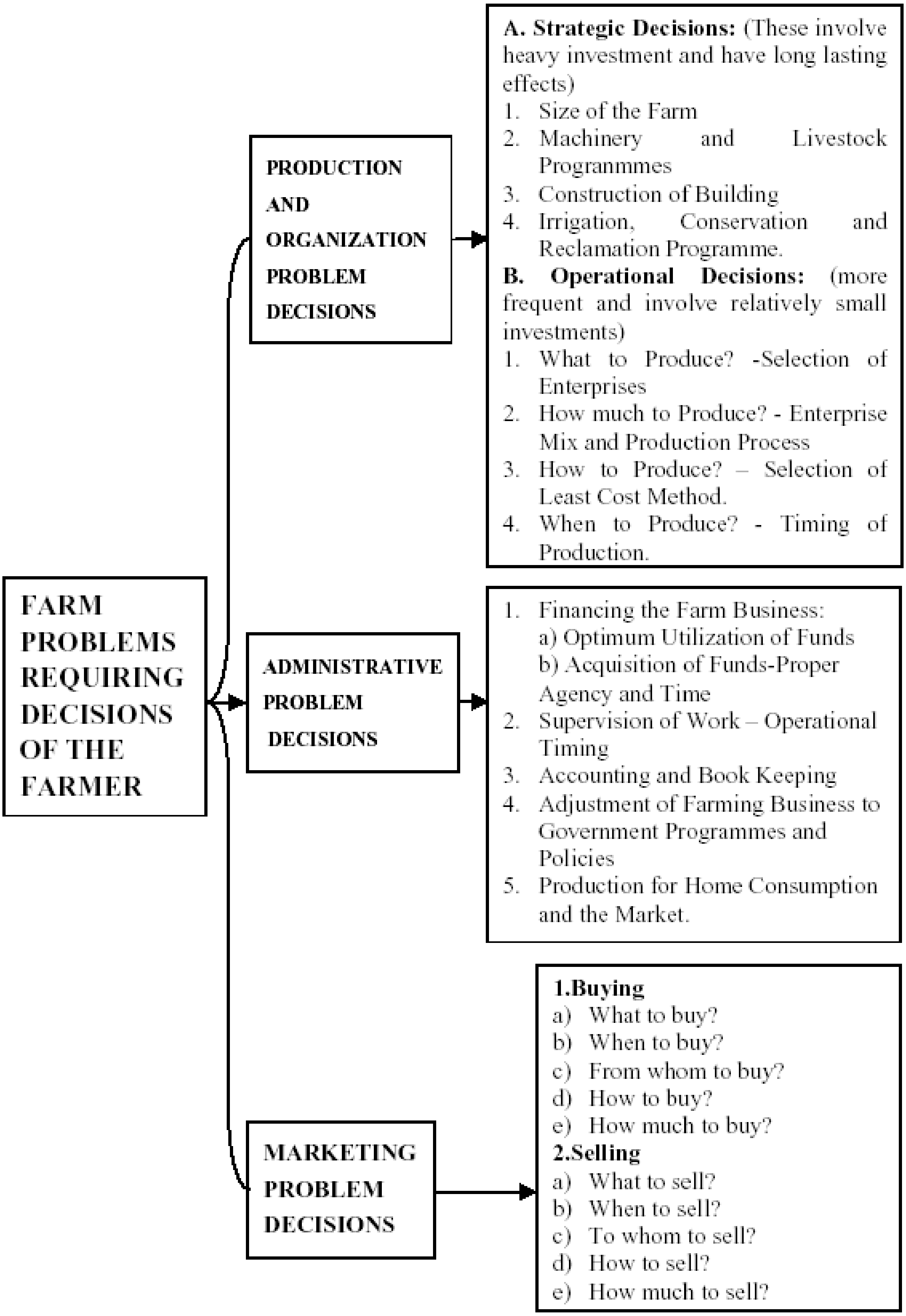
i**. Strategic Management Decisions**: These are the management decisions, which involve heavy investment and have long lasting effect. These decisions give shape to overall organization of the business.

a) Deciding the best size of the farm: The size of farm depends upon type of farm business, irrigation potential, level of mechanization, intensity of usage of land and managerial ability of the farmer. The economic efficiency of each crop/or live stock enterprise and their combinations, when they are operated on different scales, are considered to decide upon the optimum size of the holding.

b) Decisions on farm labour and machinery programmes: Deciding the most profitable combination of the factors to be used in producing a commodity is one of the important farm management decisions. What combination of farm labour and machinery should be adopted to get maximum returns? Would it be profitable to vary labour or land to better utilize a given set of machinery? These decisions are to be taken so as to reduce the cost of production.

c) Decisions on construction of buildings: Decisions on size and type of buildings involve heavy investment, which become fixed resource for the business. Type of buildings, for the present pattern and level of production depends upon the kind and level of crops or livestock produced.

d) Decisions regarding irrigation, conservation and reclamation programmes: As improvements of alkalinity, salinity and other soil defects require heavy investments, soil conservation and reclamation programmes often have to be spread over years. The choice of most economical method or a combination of methods of reclamation has to be made from among mulching, contouring, bunding, terracing and application of soil amendments, laying down of proper drainage and so on. Decision on irrigation programme is also very crucial because it involves heavy investment and it gives a flow service over long period of time and also improves the productivity of other related inputs.



Farm Management Decisions

2. Operational Management Decisions: Operational management decisions are continuously made to carry out the day-to-day operations of the farm business. The investment involved in such decisions is relatively small and hence, the impact of such decisions is short-lived. These decisions are generally: i) what to produce? ii) how much to produce? how to produce? and when to produce? A brief discussion is made on these decisions below:

i) What to produce? (Selection of enterprises): The objective of the farm business, i.e., maximization of returns, could be achieved through the best combination of different enterprises. The relative profitability of these enterprises will be useful to determine what to produce and what not to produce.

ii) How much to produce? (Enterprise mix): This decision has two aspects: Enterprise mix and resource use.

a) Enterprise Mix: Combination of crop and livestock enterprises will depend upon the level of resources available, fertility of the soil, prices of factors and products in addition to the existence of complementary and supplementary relationship. Principle of substitution is used to decide the level of each enterprise, i.e., the scarce farm resources are first used for the most profitable enterprise and then the next best profitable enterprise is considered for inclusion. However, apart from profitability of each enterprise, factors like labour availability for each enterprise, size of land holding, use of by-products, maintenance of soil fertility, relative risks, distribution of incomes over time and efficiency in the use of machine power and building are considered to decide the level of each enterprise.

b) Resource Use: The best combination and optimum level of inputs can be determined based on the substitution principle and these have to be decided for minimizing the cost of production and maximization of returns.

iii) How to produce? (Selection of least - cost / efficient method or practice): Decisions, here, are made on the best practice or combination of practices and methods, which involve the least cost. The choice making from among the various alternatives has become a management problem. Although the objective generally is to select the least cost combination of inputs methods, consideration has to be given on the availability of resources in required quality and quantity at right time.

iv) When to produce? (Timing of production): Since the agricultural production is season-bound, it's timing has to be properly decided. However, farmer faces difficulty in selecting season, i.e., normal, early or late, for a particular crop due to non-availability of inputs in time and as a result he could not fetch maximum price for the produce.

3. Administrative Decisions

Along with production and organization decision, the former has to see that the work is done in a right way. Such administrative decisions are briefly discussed below:

i) Financing the farm business: While some farmers have their own sufficient funds, others may have to borrow. The problem is two fold, viz., a) utilization of funds within the farm business, and b) acquisition of funds, i.e., proper agency, time, type, and terms of credit. Cash flow analysis would be used to decide the timing and quantum of credit required.

ii) Supervision of work: The farm manager has to ensure that each job is scrupulously done as planned.

iii) Accounting and book keeping: Collection, analysis and evaluation of data have to be done in order to assess the performance of the farm at any point of time. Here decision is to be made on the kinds of farm records, time allocation and money to be spent on this activity.

v) Adjustments to government programmes and policies: Government programmes and policies on food zones, restriction on product movements, price support policy, input subsidy, etc. influence farm production and marketing. The farmer has to decide on the level of production and resource-use with the maximum economic efficiency at the farm level consistent with the government policies concerned.

4. Marketing Decisions

A farm manager has to buy various farm inputs and sell out the produces in which he has to take rational decisions. While purchasing inputs he has to consider the following aspects: a) what to buy? b) when to buy? c) from whom to buy? d) how to buy? and e) how much to buy? Similarly, in selling out the farm produces he has to carefully ponder over the following points in order to maximize his farm income: a) what to sell? b) when to sell? c) to whom to sell? d) how to sell? and e) how much to sell?

vii) Relationship between Farm Management and Other Sciences

Farm management is an integral part of agricultural production economics. Farm management is an intra farm science whereas agricultural production economics is an inter farm or inter region science. The distinction sometimes made between production economics and farm management is based on macro and micro level contents respectively. In so far as various agricultural economic problems regarding agricultural finance, land tenure, marketing, etc, are concerned at farm level, the field of specialization related to each problem becomes an integral part of farm management.

Farm management is closely related with other social sciences like psychology and sociology (Fig.1). Farmer's ability to bear risk and uncertainty is influenced by his psychological characteristics. His decisions are also influenced by the customs, habits and cultural values of the society in which he lives. The acceptance of new production techniques and methods in farming is influenced by political decisions of the government like restriction or encouragement of growing of crops, ceiling on land holding, price policies, etc.

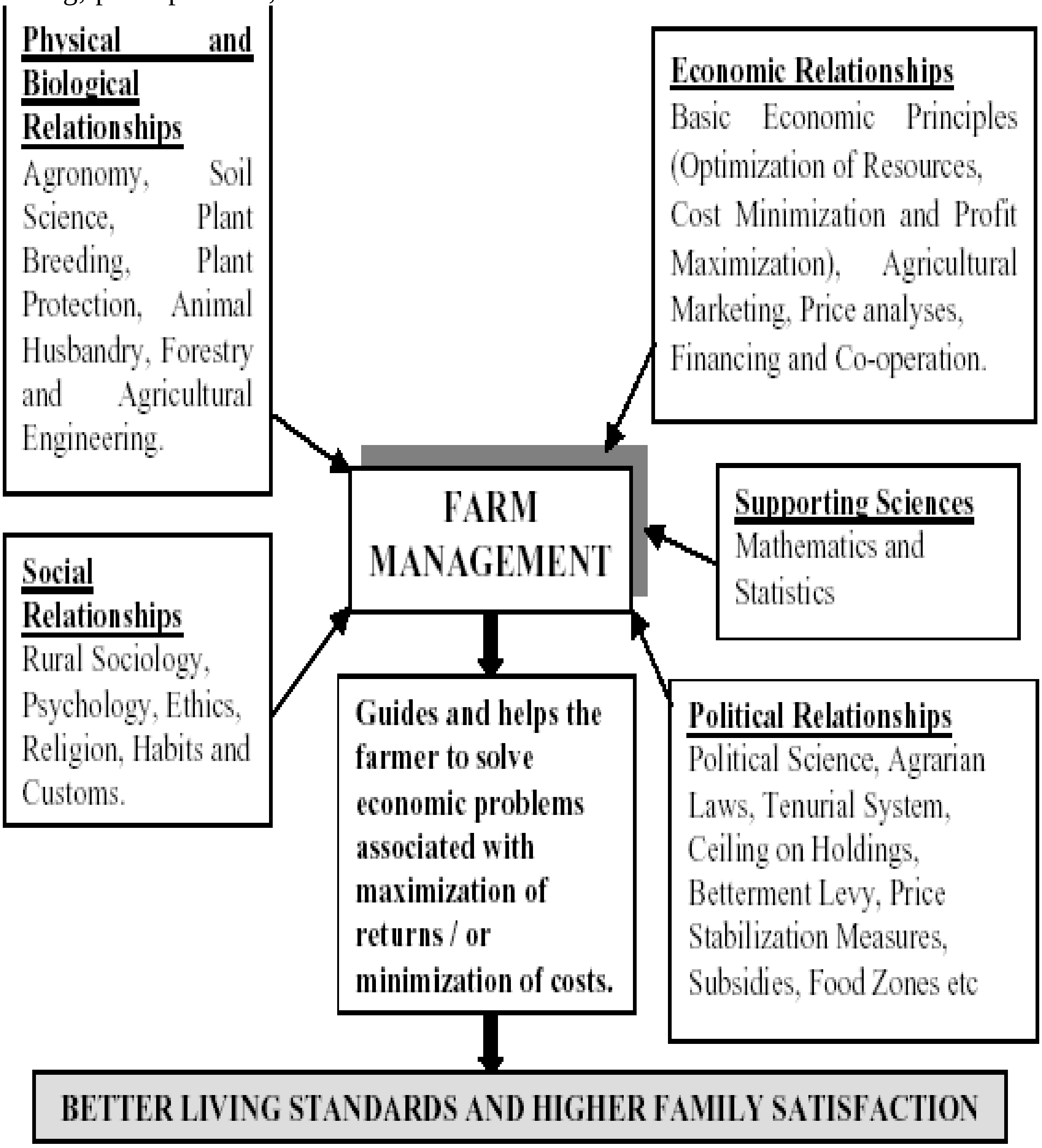


Fig.1 Relationship between Farm Management and Other Sciences

Statistics is another science that helps in providing methods and procedures by which data regarding specific farm problems can be collected, analyzed and evaluated.

Farm management relies closely on other branches of agricultural sciences such as agronomy, soil science, plant protection studies, animal husbandry, agricultural engineering, forestry, etc. These physical and biological sciences are not directly concerned with economic efficiency. They provide input-output relationships in their respective areas in physical terms, i.e., they define production possibilities within which various choices can be made. It is the task of the farm management specialist and agricultural economist to determine how and to what extent the findings of these sciences should be used in farm business management.

viii) Characteristics of Farming as Business: Farming as a business has many distinguishing features from most of other industries in their management methods and practices. The major differences between farming and other industries are:

1) Agricultural production is biological is nature.

2) Agricultural production heavily depends on agro-climatic conditions.

3) Agricultural production is carried out mostly in small - sized holdings.

4) Frequent and speedy decisions are to be taken up in agricultural production. For instance, there is no time to consider the merits of paying more wages to drain the field when there is a sudden monsoon floods.

5) Agricultural prices and production usually move in opposite direction.

6) Lack of standardization of practices and products: By the use of machines and trained personnel, it is possible to produce large volume of products exactly the same in size, form and quality. Such standardization of practices and products is not possible in agriculture. Grading system for agricultural commodities is also very weak.

7) Slow turn -over: It takes long time to recover the investment.

8) Farm financing is more risky due to drought, pest and disease attack, yield variations, etc.

9) The proportion of fixed cost is more in agriculture and so adjustment and substitution of resources are more difficult.

10) Inelastic income demand for farm products: As income increases, the demand for agricultural products will increase in lesser proportion when compared with industrial goods.

11) Perishable and bulky nature of agricultural commodities cause storage, processing and transportation problems.

12) Lack of Knowledge: All farmers do not know the latest developments in agricultural technologies.

13) Agricultural markets are not regulated properly and there are too many middlemen in the agricultural marketing system, whereas in industry, the distribution channels are well defined and controlled by producers.

14) Agriculture is considered not only a means of livelihood but also a way of life to the farmers in all the under developed countries.

ix) Farm Management Problems under Indian Conditions

Farm management problems in India vary from place to place depending mostly on the degree of infrastructural development and the availability of resources. The following are some of the most common problems in the field of farm management:

1) Small size of farm business: The average size of operational holding in India was 1.55 ha in 1990-91. The holdings are fragmented, too. Unfavourable land man ratio due to excessive family labour depending upon agriculture have weakened the financial position of the farmers and limited the scope for farm business expansion.

2) Farm as a household: In most parts of the country, farmers, especially dry land farmers, follow the traditional combinations of crops and methods of cultivation. Work habits are closely associated with food commodities consumed and living conditions. Farm has become the means of livelihood of farmers and hence, subsistence farming is followed. Home management, thus, heavily influences and gets influenced by farm management decisions.

3) Inadequate capital: The new technology demands costlier inputs such as fertilizer, plant protection measures, irrigation and high yielding variety seeds as well as investment on power and machinery. But perpetual debt and low marketable surplus prevent the farmers from adopting new technologies. 4) Under employment: Unemployment results from 1) small size of farm, 2) large supply of family labour, 3) seasonal nature of production and 4) lack of subsidiary or supporting rural industries. It reduces efficiency and productivity of rural manpower.

5) Slow adoption innovations: Small farmers are usually conservative and sometimes skeptical of new techniques and methods. However, once they try a new idea and find it effective, they are eager to adopt that. The rate of adoption, however, depends on farmer’s willingness and his ability to use the new information.

6) Inadequacy of input supplies: Farmers may be willing to introduce change, yet they may face the difficulty in obtaining the required inputs of proper quality, in sufficient quantity and on time in order to sustain the introduced changes.

7) Lack of managerial skill: Due to lack of managerial skill among small farmers, adoption of new techniques and use of costly inputs could not be followed up by them.

8) Lack of infrastructural facilities: Infrastructural facilities such as marketing, transport, and communication are either inadequate or inefficient and this results in the shortage of capital and quality inputs and non-availability of inputs in time.

Lecture No.3.

Basic concepts in farm management. Production, types of resources, choice indicators, costs, revenue, profit, total, average & marginal concepts.

BASIC CONCEPTS OF FARM MANAGEMENT

The basic concepts that are frequently used in farm management are discussed below:

i) Farm-Firm: Farm means a piece of land where crop and livestock enterprises are taken up under a common management. A farm is a firm which combines resources in the production of agricultural products on the lines of a business firm, i.e., with the objective of profit maximization.

ii) Resources or Inputs or Factors of Production: Resources are those which get consumed or transformed into products in the process of production. Services of resources are also used up in the production process. All agricultural resources can be classified into two types. They are i) fixed resources and ii) variable resources.

a) Fixed resources: Level of some resources like buildings, machinery, etc.is fixed over a production-planning period irrespective of the level of enterprises taken up. These are called fixed farm resources, E.g. Land, building, machineries, etc. The quantum of fixed resources does not change with the level of production. Some of the resources, which are fixed during a short period, may become variable during a long term.

b) Variable resources: Some resources like seed, fertilizer, labour, etc vary with the level of output. These are variable resources.

Resources can also be classified into stock and flow resources as detailed below:

a) **Stock resources**: They are resources which are used up entirely in the production process. Fertilizer, seed, feed, etc., are such resources that can be stored up for using at later period.

b) **Flow resources**: Contrary to stock resources, there are factors of production which give only flow of services in the production process. Hence, they are called the flow resources. If the services of this category of resources are not utilized, they go waste, as they cannot be stored up for later use. For example, if the services of a farm building or machinery are not used in a particular day, they go waste, as they cannot be stored up for future use.

iii) Ways of Mobilizing Farm Resources: The different types of farm resources and ways of mobilizing them by a farm manager are discussed here.

a) **Owning**: Resources like land, machinery, implements, tools, work bullocks, etc, can be acquired by purchasing them. Farmers can own these resources due to the following reasons:

1) The resources are to be continuously or more frequently used throughout the year. The size of holding should be large enough to effectively use such assets.

2) If the farmer could not engage work bullocks, tractors/power tillers, power sprayers, bullock cart and so on in his own farm economically, adequate demand should be there for hiring out these resources.

3) The farmer should have either adequate owned funds or borrowed funds to acquire these resources.

Owning of resources would be convenient to the farmer especially during peak season so as to carry out the farm operation in time. However, during lean season, it may be uneconomical to maintain owned resources. E,g. Bullocks, thresher, etc. Hiring would be cheaper than owning the resource especially, when the size of holding is too small.

b) Leasing: The immovable resources like land and buildings can be acquired by leasing. Rent has to be paid based on the terms agreed by the lessees (tenants) to the owner of such resources. The land owner may lease-out his lands to land less agricultural labourers or to farmers who are capable of cultivating larger area. The land owner leases out due to 1) his absenteeism at the village where his land is located, 2) inefficiency in running farm and 3) running of other more profitable enterprise in the same village. Sometimes, the widows and invalids may lease out due to their physical inability. Leasing-in helps lessees (tenants) to augment their farm returns. However, leasing-out becomes complicated due to improper implementation of agrarian laws which are more favourable to tenants. The fertility status of the leased-out land is gradually deteriorating because the tenants do not apply organic manure and they do not properly maintain the farm assets out of the fear of eviction from the land by the owner. Therefore, the productivity of leased-out land is lesser than that of owned land. On the contrary, as the tenancy legislations are more favourable to tenants, some of them refuse to surrender their tenancy rights to the owners and hence, the owners are reluctant to lease out their lands.

c) Hiring: The farmer can acquire human labour and bullock power through hiring. The magnitude of employment of hired human labour and bullock power depends upon: a) size of farm holding, b) number of family labourers available, c) availability of owned bullocks, d) resourcefulness of the farmer to replace labour with capital and e) diversification of crop activities practiced in the farm. Hiring of human labour and bullock power is also difficult and costly during peak season due to either costly human labour as a result of heavy demand for such labour or difficulty in carrying the operations with human labour in time. However, hiring of human labour and bullock power is more economical than that of hired machinery to small and marginal farms, especially in areas where the labour is cheaper.

d) Joint ownership: When the land, buildings and well are inherited by legal heirs, the land gets sub-divided and buildings and wells are jointly owned among them. Joint ownership is convenient and economical to those who have small and fragmented inherited land. However, disputes arise due to lack of understanding among joint owners in sharing the services and also in the maintenance of the jointly owned assets.

e) Custom Services: Farmers could acquire custom services of machineries like tractor, power tillers, threshers, power sprayers, etc. by paying custom hire charges. Hiring of custom services of machineries depends upon 1) size of farm holding, 2) availability of alternatives such as human labour and bullock power, 3) hire charges for human labour and bullock power, 4) custom hire charges, 5) time of operation (peak or lean season), 6) availability of time to carry out the farm operation and 7) quantum of work to be carried out. Custom services would be more economical for small and marginal farms as they cannot afford to buy or maintain costlier equipments and machineries.

iv) Product or Output: It is the result of the use of resources or services of resources. The resources get transformed into what is known as output. E.g. Paddy, groundnut, sugarcane, milk, etc.

v) Production: It is a process of transformation of resources or inputs like labour, seed, fertilizer, water, etc. into products like paddy, wheat etc.

vi) Transformation or Production Period: The time required for a resource to be completely transformed into a product is called transformation or production period. E.g. Paddy is harvested in 3½ to 6 months.

vii) Production Economics: Farm production economics is a field of specialization within the subject of agricultural economics. It is concerned withchoosing of available alternatives or their combinations in order to maximize the returns or to minimize the costs. Agricultural production economics is an applied field of science, wherein the principles of choice are applied to the use of land, labour, capital and management in farming. The subject matter of production economics explains the conditions under which the profit, output, etc. that can be maximized and the cost, use of physical inputs, etc. that can be minimized. The main objectives of production economics are:

a) to determine and define the conditions which provide for optimum use of resources;
b) to determine the extent to which the current use of resources deviates from the optimum use;
c) to analyze the factors which influence the existing production patterns and resources use; and
d) to identify the means and methods for optimal use of resources.

The principles that help attain these objectives are the same on a micro as on a regional or national level. On micro level where intra-farm resource allocation and production pattern are involved, it is the subject matter of farm management. When choice principles involve a broader field on a macro-level, the subject is known as production economics. The economist who focuses his attention on individual farm cannot make rational recommendations unless he considers the aggregate or overall aspect of production. Similarly, government programmes and policies affect the decisions on the individual farms. Production economist, therefore, must be able to integrate both individual and aggregate aspects of agricultural resource use and levels and patterns of production.

viii) Production Function: Production function refers to input-output relationship in the production process. Production function is a technical and mathematical relationship describing the manner and extent to which a particular product depends upon the quantities of inputs or services of inputs used in the production process. It describes the rate at which resources are transformed into products. There are numerous input-output relationships in agriculture because the rates at which inputs are transformed into outputs will vary among soil types, animals, technologies, rainfall, etc. Any given input-output relationship specifies the quantities and qualities of resources needed to produce a particular product.

a**) Types of Production Function:** There are different types of production functions, viz., 1) continuous function and 2) discontinuous function.

1) Continuous function: The doses or levels of input and output can be split up into small units. E.g. Fertilizers or seed can be applied to a hectare of land in quantities ranging from a fraction of a kilogram upto hundreds of kilogram

2) Discontinuous or Discrete function: Such a function is obtained for input or factors or work units which are used or done in whole numbers such as one ploughing or a

number of ploughings.

The difference between discrete data and continuous data is, thus, in the divisibility of the inputs or outputs. An example of a discrete input is a cow. A dairy herd may be composed of two, three, or most cows. However, one and a half, three and a quarter, etc, will not be found in a dairy herd. Fertilizer on the other hand is an example of a continuous input. Fertilizer can be divided into any size unit and for each size unit, there is a resulting yield.

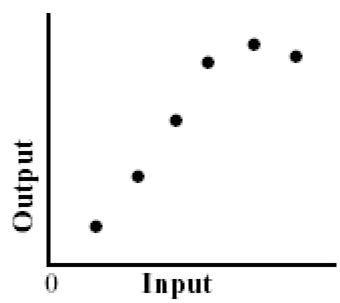


Fig.9.1 (a) Discrete Production Function

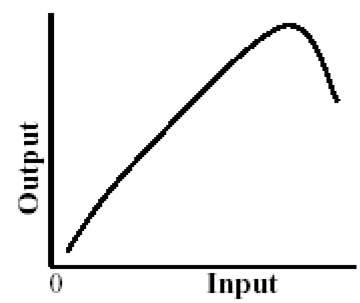


Fig.9.1(b) Continuous Production Function

The production function can also be classified into 1) very short run production, 2) Short run production function and 3) Long - run production function.

1) Very short run production function: The time period is so short that all resources are fixed.

2) Short run production function: Production function, which relates factors and products where some resources are fixed, can be termed as short run production function. The time period is of such length that at least one resource is varied while other resources are fixed.

3) Long - run production function: Production function, which permits variation in all factors (none is fixed), can be called long-run production function. The time is of such length that all resources can be varied.

The production function relates output (Y), to input (X). The definition of a function is as follows: If an output (Y) depends upon an input (X), then Y is called a function of X. The mathematical expression for a function is Y = f (X). This functional notation is read, "Y is a function of X". Y is usually called the dependent variable, and X, the independent variable.) Subscripts: Subscripts are useful when symbols are used. Consider, for example, the notation for the production function Y = f (X), where X is the amount of input and Y, the resulting amount of output. In this, there can be no confusion about identification of input or output because there is only one input and one output. When more than one input or output is included in a problem, subscripts can be used as a means of identification. For example, when output is a function of three inputs, the production function can be written $Y = f(X_1, X_2, X_3)$, where X_1, X_2 and X_3 are distinct and different inputs. X_1 may be seeds; X_2 may denote labour and X_3 may indicate fertilizer. If amounts are to be denoted, additional subscripts must be used. X_{11} is an amount of X_1; X_{12} is a greater amount of X_1; X_{21} is an amount of X_2; X_{22} is a greater amount of X_2; etc. Subscripts can also be used to identify outputs or any other variable. Thus, Y_1, Y_2 and Y_3 can be distinct outputs and the amounts can be shown by adding another subscript.

c) The "Δ" (Delta) Notation: The change in any variable is denoted by "A" (the Greek letter "delta") placed before the variable. For example, the change in the variable X is denoted by AX. Production function is written as: $Y = f(X_1, X_2, X_3, \ldots, X_n)$ where, Y is output and X1, ..., X_n are different inputs that are used in the production of a product or output. The functional symbol "f" indicates the form of relationship that transforms inputs into output. For each combination of inputs, there will be a unique level of output. For example, Y may represent paddy yield, X_1, quantity of seed, X_2, quantity of fertilizer, X_3, labour and so on. The above notation for a production function does not specify which inputs are fixed and which are variable. For example, seed or fertilizers are variable inputs that are combined with fixed input such as acre of land. Symbolically, fixed inputs can be included in the notation for a production function by inserting a vertical line between the fixed and variable inputs. For example, $Y = f(X_1, X_2, X_3, \ldots X_{n-1} \mid X_n)$ states that X_n is the fixed input while all other inputs are variable.

d) Forms of Production Function: The technical functional relationship between resources/inputs and product can be expressed by a functional form, a few of which are given below:

1) Linear: The simplest form of linear production function is $Y = a + bX$ with one variable input and $Y = a + b_1X_1 + b2X2 + b3X3 + \ldots + b_nX_n$ with n variables. n

Symbolically, $Y = a + \sum_{i=1}^{n} b_i X_i$ - where, Y is output, a - constant, bi – unknown parameters to be estimated and Xi - variable inputs. The estimated equation is:

$$Y = 0.2151 + 0.0412X_1 - 0.0002X_2 + 0.0752X_3 - 0.0066X_4 - 0.0880X_5$$

$R^2 = 0.64$; $F = 3.56$.

The values of Xi's indicate the rate of change in Y due to one unit change in Xi's. For example, an unit change in X_1 results in 0.0412 units increase in Y when all other variable inputs are kept constant at their respective mean levels,

i.e., *ceteris paribus.*

2) Cobb-Douglas Production Function (or) Power Function: The power production function is a non-linear production function which is more commonly known Cobb-Douglas production function, after the names of persons who first applied it for empirical estimation and it is represented as:

$$Y = AL^a K^b$$

Where, L and K are labour and capital respectively and Y, the output. A, a and b are parameters to be estimated. This can be generalized to 'n' inputs also.

$$Y = a0\ X1^{a1}\ X2^{a2} \ldots Xn^{an} = a0\ \Pi\ Xi^{ai}, \ i = 1, 2, \ldots, n.$$

Since the model in the above equation is in multiplicative form, it has to be converted into log-linear form so as to estimate parameters and it is given below:

$$\ln = \ln a0 + a1 \ln X_1 + a2 \ln X2 + a3 \ln X3 + \ldots + an \ln Xn \ n$$

$$\ln = \ln a0 + \sum_{i=1} ai \ln Xi, \text{ where, } i = 1,2,3,\ldots,n$$

In the above function, a_0 and ai are the efficiency parameters and elasticity of production with respect to the input Xi, respectively. The result of the Cobb Douglas production is as follows:

$$Y = 0.7342\ X1^{0.6315}\ X_2^{0.0234}\ X3^{-0.0496}\ X4^{0.1904}\ X5^{0.0760}\ X6^{-0.0286}\ X7^{0.0871}$$

The regression co-efficients indicate the percentage increase in Y with respect to one per cent increase in the input X. For example, if we increase X_1 by one per cent, holding other resources at a constant level, Y will increase by 0.6315 per cent, thus showing diminishing return with respect to X_1, say, land in hectares. The sum of elasticities turns out to be less than unit (0.9302), which indicates diminishing return to scale.

3) Quadratic Form: The quadratic equation $Y = a + bX_1 - cX_1^2$, with a minus before C denotes diminishing returns. It allows both a declining and negative marginal productivity, but not both increasing and decreasing marginal products.

ix) Total Physical Product (TPP): TPP is the quantum of output (Y) produced by a given level of input (X).

x) Average Physical Product (APP): APP is the quantity of output produced per unit of input i.e., ratio of the total product to the quantity of input used in producing that amount of product.

$$APP = \frac{\text{Number of Units of Output}}{\text{Number of Units of Input}} = \frac{Y}{X}$$

xi) Marginal Physical Product (MPP): The term marginal refers to an additional unit. If we use A (delta) to mean “change in “, then AY and AX represent change in Y (output) and change in X (input) respectively. Marginal physical product, therefore, refers to the change in output, which results from applying an additional unit of input.

$$\text{Marginal Physical Product (MPP)} = \frac{\text{Change in Output}}{\text{Change in Input}} = \frac{A\,Y}{A\,X}$$

Lecture No.4.

Factor - Product relationship - Production function - definition & types - linear, quadratic & Cobb- Douglas functions - Impact of technology.

Factor – Product Relationship (Or) Input – Output Relationship

The objective of factor-product relationship is to determine the optimum quantity of the variable input that will be used in combination with fixed inputs in order to produce optimal level of output. Further questions such as, how much fertilizer to be applied per acre? how much irrigation to be given? and so on are all within the scope of factor – product relationship. There can be three types of input-output relationships in producing a commodity where one input is varied and the quantities of other inputs are fixed. The nature of relationships between a single input and a single output can either be of the one or a combination of types given below:

i) Constant Marginal Rate of Returns or Law of Constant Returns.

ii) Increasing Marginal Rate of Returns or Law of Increasing Returns.

iii) Decreasing Marginal Rate of Returns or Law of Decreasing Returns.

A. LAWS OF RETURNS

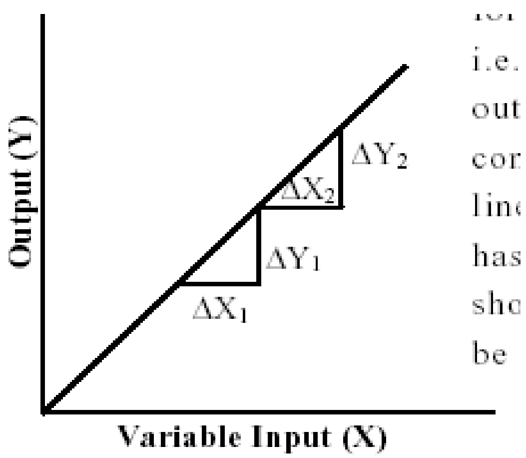


Fig. 10.1.Law of Constant Returns

Let us consider the simplest case where one product is produced by varying the level of only one factor of production at a time.

Law of Constant Returns: The level of output increases by an equal amount for each additional units of the variable input i.e., the relationship between the input and the output is linear. Thus, graphically, the law of the law of constant returns can be depicted by a straight-line production function. The production functionhas the same slope throughout its entire range asshown in the figure 10.1. Mathematically, it canbe

$$\frac{\Delta Y_1}{\Delta X_1} = \frac{\Delta Y_2}{\Delta X_2} = \ldots = \frac{\Delta Y_i}{\Delta X_i} = \ldots = \frac{\Delta Y_n}{\Delta X_n} = k$$

Where $\Delta Y_i / \Delta X_i$ is the marginal product due to the use of the i^{th} unit of variable input, X (i = 1, 2,…,n) and k is a constant. Such constant returns can occur under two situations:

a) No resource is fixed and all the inputs are varied, increased or decreased together.

b) One or more factors of production may be fixed but they have surplus (unutilized) capacity. The constant returns may be explained with the data given

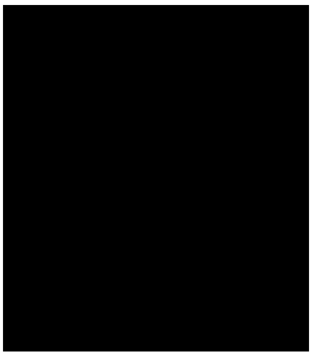
Table 10.1 Yield of Maize at Varying Levels of Nitrogen per Hectare

Variable Inputs (Kg of N per ha)	ΔXi	Output (quintals of Maize per ha)	ΔYi	$MPP = \frac{\Delta Y_i}{\Delta X_i}$
0	-	25	-	-
25	25	26	1	0.04
50	25	27	1	0.04
75	25	28	1	0.04
100	25	29	1	0.04

:The table (10.1) shows that every addition of 25 Kg of nitrogen ΔXi causes exactly the same increase of one quintal in the yield of maize per ha (ΔYi) during the process of production.

stated as under:

ii)



Variable Input(X)

Fig.10.2 Law of Increasing Returns

Law of Increasing Returns: Increasing returns are said to operate when every successive unit of the variable input results in a larger increase in the output as compared

At lower level of fertilizer

increase when fertilizer application is increased upto a certain level. The following table illustrates the law of increasing returns with the help of data on

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to the preceding unit. Such an input-output relationship is generally encountered at a relatively lower level of input use. The resulting production function is a non-linear curve of the type shown in the figure 10.2 and is convex to the input axis. Mathematically, the law can be

$$\frac{\Delta Y_1}{\Delta X_1} < \frac{\Delta Y_2}{\Delta X_2} < \ldots < \frac{\Delta Y_i}{\Delta Xi} < \ldots < \frac{\Delta Yn}{\Delta Xn}$$

where, AY $_i$ /Xi , .i = 1, 2, 3, . . . , n is the marginal product due to the use of .i th unit of

the variable input (X). Thus, in terms of marginal productivity of the variable factor of production, the law of increasing return signifies an increasing marginal product with n addition of every successive unit of the variable resource paddy yield at varying levels of nitrogen application. The example given in the table (10.2) indicates the response of paddy yield to increasing nitrogen application at a very low level of the input-use. It may be observed that as the input is increased from 0 to 25 kgs per hectare, a dose of 5 kg at each step, the

Table 10.2 Yield of Paddy at Varying Levels of Nitrogen per Hectare

Variable Input (Kg of nitrogen per Ha)	AXi	Output (Quintals of paddy per Ha)	A Y ;	MPP = AYi / AXi
0	-	20.0	-	-
5	5	21.0	1.00	0.20
10	5	22.5	1.50	0.30
15	5	24.5	2.00	0.40
20	5	27.0	2.50	0.50
25	5	29.7	2.70	0.54

yield increases by 1.0, 1.5, 2.0, 2.5 and 2.7 quintals per hectare. Thus, every successive dose of 5 Kgs of nitrogen results in more output of paddy signifying the operation of the law of increasing returns.

iii) Law of Diminishing Marginal Returns: When one variable input used for the production of a certain commodity is increased relative to other inputs, the physical output obtained from each added unit of the variable input(s), tends to decline after a certain point has been reached. Thus, each additional unit of the variable input results in less and less addition to the total output as shown in the

figure 10.3. Mathematically,

AY1A Y2 A Yi AYn

X1A X2 AXi AXn

Variable Input (X)

Fig. 10.3 Law of Decreasing Returns

where AY i / AXi , i =1, 2, 3, . . . n is the marginal product due to the use of ith unit of the variable input (X). Thus, the marginal productivity of the variable input X goes on declining with the increasing level of total output as a result of more intensified use of the variable factor. This type of return can be shown geometrically by a non-linear curve of the type shown in the figure 10.3. Such a curve would be concave to the input axis and convex upwards.

We can also demonstrate the operation of this law with the help of data on nitrogen application and yield of paddy per hectare in

The table 10.3 would reveal that as more of the variable input (X) is used, the yield of paddy also keeps on increasing till 90 kgs of nitrogen application and results in 69 quintals of paddy yield per ha. However, the paddy yield remains unchanged when the variable input level is increased from 90 to 120 Kg per hectare. Further, it could be noted that every addition of one kg of nitrogen nutrient (AXi) adds less and less of output, i.e., from 0.60 to 0.33, from 0.33 to 0.13 and so on. This is a technological law of biological responses and is

Table 10.3 Yield of Paddy at Varying Levels of Nitrogen per Hectare

Variable Input (Kgs of Nitrogen per Ha)	AXi	Output (Quintals of Paddy per Ha)	AYi	MPP = A Yi
0	-	37	-	-
30	30	55	18	0.60
60	30	65	10	0.33
90	30	69	4	0.13
120	30	69	0	0

applicable in almost all-practical situations of agricultural production under varied farm situations. This law also refers to diminishing marginal productivity of a variable factor of production, with other factors held constant at some specified levels, as its use is intensified.

Lecture No. 5

Law of diminishing returns - 3 regions of production

a) Law of Diminishing Marginal Returns (LDMR)

Alfred Marshall stated the law thus: “An increase in labour and capital applied in the cultivation of a land causes, in general, a less than proportionate increase in the amount of produce raised, unless it happens to coincide with an improvement in the arts of agriculture”.

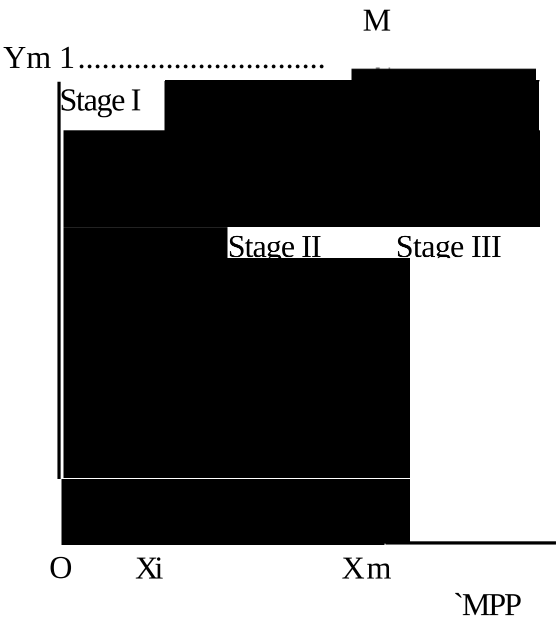
The advancement in agricultural technology may bring about changes where the operation of this law is delayed, for example, by evolving, varieties of crops, which give higher yields at higher levels of fertilizer application. But so far, science has not succeeded in stopping the operation of this law in agriculture. The law of diminishing returns is also called the law of variable proportions. E.O. Heady has stated that if the quantity of one productive service is increased by equal increments, with the quantity of other resource services held constant, the increment to total product may increase at first but will decrease, after a certain point. In other words, as the amount of a variable resource used in the production of an output is increased, the level of output will at first increase at an increasing rate, then increase at a decreasing rate and finally a point will be reached, where further applications of the variable resource will result in a decline in the total output of the production.

b) Relationship between Total, Average and Marginal products (or) Three Stages or Phases or Zones of Production Function: Since both average and marginal products are derived from total product, the average and marginal product curves are closely related to the total product curve. The input-output relationship showing total, average and marginal productivity can be divided into three regions in such a manner, that one can locate the portion of the production function, in which the production decisions are rational. A non-linear total product curve and the three zones of production are shown in the figure 10.4.

Stage I: As we increase the level of a variable input, say seed rate per hectare, the total production (yield per hectare) increases at an increasing rate till point 'L' is reached on the TPP curve. Thus, upto this point (L) the marginal physical product (MPP) is shown as increasing and then it starts declining. Point L is the point of inflection on the TPP curve where the curvature changes from convex to concave to the input axis as we move away from origin. The TPP curve is continuously increasing but at a decreasing rate as we move from the point L to M on TPP by increasing the seed rate from Xi to Xm. The stage I ends at the point N where marginal product is equal to average product when the latter is at its maximum. In this stage, APP keeps on increasing and MPP remains greater than APP. It is not reasonable to stop the use of an input when it's efficiency-in

use is increasing (This is indicated by continuous increase in APP). In this stage, more use of variable input increases its physical production efficiency in combination with fixed inputs. So it is irrational to stop increasing the use of variable input, as long as

fixed inputs are not fully utilized. For this reason, it is called irrational stage of production.



Variable Input *(X1) Fig 10.4 Three Zones*

Stage II: The Stage II occurs when MPP is decreasing and is less than APP. In Stage II, MPP is equal to or less than APP but equal to or greater than zero. It starts at a point where APP is at its maximum and ends where the total product is at its maximum. Within the boundaries of this region is the area of economic relevance. It is only in this region that marginal product of variable and fixed factors are positive. Optimum point of input-use must be somewhere in this region. Hence, it is called rational stage of production. The optimum point can, however, be located only when input and output prices are known. It needs to be emphasized that this region of rational production embodies diminishing returns phase. Both average and marginal products are decreasing in this region.

Stage III: A part of TPP curve beyond the point M is called the third phase of production. As variable input use is extended beyond X_m, the marginal product beyond point M is negative. It is irrational to increase the input level for obtaining lower total product. Thus, Stage III is also called irrational stage of production. The difference between the irrationality in Stage I and Stage III can be explained in terms of scarcity of the variable input in Stage I and its excess use in Stage III in relation to the fixed factors of production. Thus, while the marginal product of the variable factor is negative in the third stage of production, the same is precisely true for the fixed factor in the first stage of production. E.g.) more fertilizer dosage, excessive irrigation, etc. would result in reduction of yield.

Total physical product function (TPP): $Y = 4X+2X^2- 0.1X^3$

Average physical product function (APP): $Y/X = 4+2X-0.1X^2$
Marginal physical product function (MPP): $= dY / dX = 4 + 4X - 0.3X^2$ c)

Relationship between APP, MPP and Elasticity of Production

The elasticity of production refers to the percentage change in output in response to the percentage change in input. It can be denoted by Ep and can be computed as:
computed as:

$$Ep = \frac{\left[\frac{\Delta Y}{Y} \times 100\right]}{\left[\frac{\Delta X}{X} \times 100\right]} = \frac{\left[\frac{\Delta Y}{Y}\right]}{\left[\frac{\Delta X}{X}\right]} = \frac{\Delta Y}{\Delta X} \times \frac{X}{Y}. \text{ Therefore, } Ep = \frac{\Delta Y}{\Delta X} \times \frac{1}{Y/X} = \frac{\mathbf{MPP}}{\mathbf{APP}}$$

Thus, elasticity of production can also be worked out if MPP and APP are known. In the figure 10.4, at the end of stage I, the Ep is unity (a one per cent increase in input is always accompanied by a one per cent increase in output). In stage I, MPP is greater than APP. Therefore, Ep is greater than 1. In stage II, MPP is lesser than APP and Ep is lesser than one, but greater than zero,

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(0 <_ Ep <_ 1). In stage III, MPP is negative and Ep is also negative. E.g. when X increases from 0 to 1 unit and Y increases from 0 to 5,

$$Ep = \frac{5\ (0 + 1)}{1\ (0 + 5)} = 1.00$$

When X increases from 1 to 2 units and Y increases from 5 to 11 (Arc elasticity method),

$$Ep = \frac{6\ (1 + 2)}{1\ (5 + 11)} = \frac{18}{16} = 1.125.$$

d) Impact of Technological Change on Production Function: Technology is the knowledge applied by man to improve production or marketing process. The physical and value productivities of farm resources have been changing continuously due to the constant flow of innovations in agriculture. Technology can help producing more quantity of product per unit of input. This means that more total output can be produced from inputs that were used prior to the technological innovation, or the same amount of total product can be produced with fewer resources. There can be different levels and grades of technology available to a farmer. For example, application of fertilizer is possible with the broadcast method, band application and or spray method. Use of same quantity of the fertilizer through different methods (technologies) will give different yield levels. Similarly a different variety of a crop (paddy) such as white *ponni*, IR20, IR 50, etc will give different yields. For the same quantity of input, different yield levels can be obtained (Y_1, Y_2 and Y_3) using different types of technologies (T T and T) as shown in 1,23 Fig.10.5. The technological advances result in:

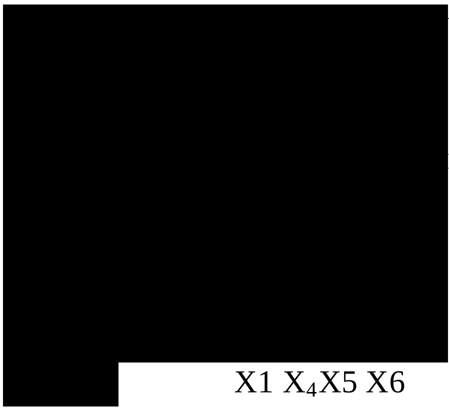

Fig.10.5 Impact of Technological Change on Production Function

1) Factor saving technologies, or cost reducing technologies, such as development of improved tractors.

2) Yield increasing technology – high yielding varieties and hybrid varieties.

3) Both factor saving and yield increasing technology.

Lecture No.6

Cost concepts & interrelations - Optimum level of input use and optimum production

B. COSTS

Production costs play an important role in the decisions of the farmers. Explicitly or implicitly, most of the producers keep in mind the cost of producing additional units of output. In general, at given level of prices, a farmer can increase his farm income in two ways, i.e., i) by increasing production and / or ii) by reducing the cost of production. Since cost minimization is an individual skill, degree of success in this direction directly adds to the profits of the farm.

Costs refer to the money value of effort extended or sacrifice made in producing an article or rendering a service or achieving a specific purpose. Costs, thus, are the expenses incurred in organizing and carrying out the production process. They include outlays of funds for inputs and services used in production. Money value of all inputs used in the production process is termed as the total cost. If the inputs used are represented by X_1, X_2,..., Xn and the

respective prices by Px_1, Px_2, ..., Px_n, then the total cost (TC) can be expressed as: TC $= Px_1.X1 + Px_2.X_2 + ... + Pxn\ Xn$.

i) Total costs: The total cost comprises of two components, i.e., fixed and variable costs. Costs of fixed inputs are called fixed costs, while costs of variable inputs are called variable costs. TVC and TC increase as output increases. Fixed costs do not change in magnitude as the amount of output of the production process changes and are incurred even when production is not undertaken, i.e., fixed costs are independent of output. Land revenue, taxes, contractual payments such as rent and interest on capital for the use of fixed resources, and the value of services from fixed resources all represent fixed costs. In farming, cash fixed costs include land taxes, rent, insurance premium, etc. Non-cash fixed costs include depreciation of building, machineries and equipments caused by the passing of time, interest on capital investment, charges for family labour and charges for management. Variable costs constitute the outlay of funds that are a function of output in a givenproduction period, i.e., they vary with the level ofoutput. The outlays of funds on seed, fertilizer,insecticide, casual labour, fuel and oil, feeds, etc, area few examples of variable costs. Total fixed costsand total variable costs are denoted by TFC and TVCrespectively. In short run, total costs include fixed andvariable costs. When no variable input is used,TC=TFC. The TC curve at any point is equal to thevertical addition of TFC and TVC. In the long run, allcosts are considered variable costs because all inputsare variable. Conventionally, total cost (TC) is thought of as a function of output (Y), rather than that of inputs, i.e., TC = f (Y).Such a cost curve is illustrated with TC on the vertical axis and Y (output)

on the horizontal axis. The total cost curve is similar to the production curve, when the physical units of X (input) have been replaced with the corresponding cost (PxX). Hence, the shape of the TC curve, like that of the TVC curve, depends upon the production function. In symbolic notation, TC can be written as

TC = TFC + TVC = TFC + Px X, where TVC = PxXii)

Average Fixed Cost, Average Variable Cost and Average Total Cost

a) Average Fixed Costs (AFC): Average fixed costs, (AFC) are computed by dividing total fixed costs by are amount of output. AFC varies depending on the amount of production.

AFC=TFC/Y

b) Average variable cost, AVC: It is computed by dividing total variable cost by the amount of output. AVC varies depending on the amount of production. The shape of the AVC curve depends upon the shape of the production function while AFC always has the same shape regardless of the production function.

c) Average Variable Cost and Average Physical Product: Average variable cost is inversely related to average physical product. When APP is increasing, AVC is decreasing. When APP is at its maximum, AVC attains a minimum value. When APP is decreasing, AVC is increasing. Thus, for a production function, APP measures the efficiency of the variable input, while AVC provides the same measure for cost curves. When AVC is decreasing, the efficiency of the variable input is increasing; efficiency is at a maximum level when AVC is a minimum and is decreasing when AVC is increasing. The relationship algebraically is as follows:

$$AVC = \frac{TVC}{Y} = \frac{PxX}{Y} = Px\frac{X}{Y} = \frac{Px}{APP}, \text{ because } \frac{X}{Y} = \frac{1}{APP}$$

d) Average Total Costs, ATC: It can be computed in two ways. Total costs can be divided by output or AFC and AVC can be added.

ATC = TC / Y. (or) ATC = AFC+AVC.

e) Nature and Relationship between Cost Curves: The shape of the ATC curve depends upon the shape of the production function. ATC decreases as output increases from zero, attains a minimum, and increases thereafter. ATC is referred to as unit cost of production, i.e., the cost of producing one unit of output. The initial decrease in ATC is caused by the spreading of fixed costs

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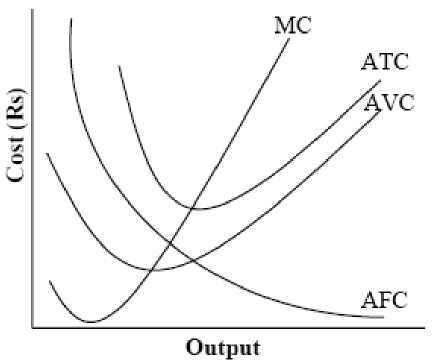


) s *Fig.10.7 Average and Marginal Cost Curves*

among an increasing number of units of output and the increasing efficiency with which the variable units is used (as indicated by the decreasing AVC curve). As output increases further, AVC attains a minimum and begins to increase; when these increases in AVC can no longer be offset by decreases in AFC, ATC begins to rise. AVC reaches its lowest point earlier than ATC.

iii) Marginal Cost, MC: It is defined as the change in total cost per unit increase in output. It is the cost of producing an additional unit of output. MC is computed by dividing the change in total costs, OTC, by the corresponding change in output, AY, i.e., MC =OTC / AY. By definition, the only change possible in total costs is the change in variable cost, because fixed cost does not vary as output varies. Thus, OTC =ATVC. Therefore, MC could also be computed by dividing the change in total variable cost by the change in output. Geometrically, MC is the slope of the TC and the TVC curve. The shape of the MC curve is in an inverse relationship to that of MPP. For lower levels of output, MC is decreasing while MPP is increasing. Algebraically, the

$$MC = \frac{\Delta TC}{\Delta Y} = \frac{\Delta TVC}{\Delta Y} = \frac{Px\ (\Delta X)}{\Delta Y} = Px \cdot \frac{\Delta X}{\Delta Y} = \frac{Px}{MPP}$$

MC and AVC are equal, where MPP is equal to APP. For lower output levels, MC is less than AVC and ATC and for higher output levels, MC is greater than AVC and ATC. As long as there is some fixed costs, MC crosses ATC at an output greater than the output at which AVC is at the minimum and MC is equal to ATC at the latter's minimum point. MC curve will intersect the AVC and ATC curves at their lowest point from below.

Costs need be computed and graphed for input and output amounts only in stages I and II of the production function; stage III is an area in which no rational manager would produce. Stage II begins at the point where MC=AVC

and continues to the point where output is a maximum.

$TC = 100 + 8Y - 0.4Y^2 + 0.02Y^3$

TFC = 100135

$TVC = 8Y - 0.4Y^2 + 0.02Y^3$ AVC =

$TVC = 8 - 0.4Y + 0.02Y^2$

Y

AFC = TFC = 100

Y Y

$ATC = AFC + AVC = 100Y^{-1} + 8 - 0.4\ Y + 0.02Y^2$

$MC = \frac{dTVC}{dY} = 8 - 0.8\ Y + 0.06Y^2$

iv) Methods of Determining the Optimum Level

The problem here is to determine the most profitable point of operation for an enterprise in the short-run. This can be done by determining either the most profitable amount of input or the most profitable level of output. As the production function relates the input to output in a unique manner in stage II, either method results ultimately the same answer. In economic terminology, the "most profitable" amount can be called the "optimum" amount.

a) Determining the Optimum using Total Value Product and Total Costs: Total Value Product, TVP, is the total value of the production of an enterprise. TVP = Py. Y, where Py is the price per unit of the output and Y is the amount of output at any level of input X. Total value product minus total cost is the profit which is also called net returns or net revenue. As output increases, profit increases and reach a maximum of Rs.30 at 8 units of input and 28 units of output as could be seen from the table 10.4. Maximum profit from an enterprise does not necessarily occur where output is at its maximum. Output reaches a maximum of 29 units at 9 units of input. Therefore, the point of maximum yield is not necessarily the same as the point of maximum profit. Profit = TVP – TC = TVP –TVC – TFC = Py.Y – Px X – TFC.

b) Determining the Optimum Amount of Input

The criterion for determining the optimum amount of input is derived from the slopes of total value product and total cost curves, when those curves are plotted as functions of the input, X. First, consider the profit equation as the function of input.

Profit = Py. f(X) – Px X – TFC, where, Y = f(X).

In order to maximize this function with respect to the variable input, the first derivative is set to zero as follows:

$$\frac{d\,(\text{Profit})}{dX} = Py\,\frac{dY}{dX}\; Px = 0$$

$$= Py.MPP - Px = 0$$

$$\mathbf{Py.MPP = Px\,,\ \ i.e.,\ VMP = Px.}$$

But, the term Py. MPP is the slope of TVP curve and is called the Value of Marginal Product (VMP). The term Px is the slope of the total cost function. In pure competition, Px will always be constant. Dividing both sides of Py, we get,

$MPP = \dfrac{Px}{Py}$. So, another method of stating the marginal criterion is to say that the marginal product of variable input must equal the inverse ratio of prices (input - output price ratio).

c) Determining the Optimum Amount of Output

The marginal conditions for the maximization of profit as a function of output can be derived from the following profit function:

Profit = TR – TC = Py.Y – Px. X – TFC =Py.Y – Px.f^{-1} (Y) – TFC where, the concept of the inverse production function must be used to express X as a function of Y. That is, $X = f^{-1}(Y)$ in stages I and II. Taking the derivatives of profit with respect to Y results in:d (profit)

$$\frac{d\,(\text{profit})}{d\,Y} = Py - Px\,\frac{dX}{dY} = 0$$

$$= Py - \frac{Px}{MPP} = 0$$

$$\mathbf{Py = MC}\cdot \quad \text{Since } MC = \frac{Px}{MPP}$$

Therefore, Py = MC at the optimum output level. Differentiation of profit equation with respect to Y would give .d (Profit)

$$\frac{d\,(\text{Profit})}{d\,Y} = \frac{d\,TR}{dY} - \frac{d\,TC}{dY} = 0$$

$$\frac{d\,TR}{d\,Y} = \frac{d\,TC}{dY} \quad \text{i.e., } \underline{\mathbf{MR=MC}}$$

where, the change in TR with respect to Y is defined as Marginal Revenue, MR, while the change in TC with respect to Y is the Marginal Cost, MC. In pure competition Py = MR.

d) Comparison of Input and Output Criteria: All methods of determining the most profitable level of output or input lead to comparable answers. The input criterion VMP = Px can be written as Py. MPP = Px (or)

$$Py.\frac{\Delta Y}{\Delta X} = Px\ .\ \ \text{That is, } Py.\ \Delta Y = Px.\ \Delta X$$

Table 10.4 Product-Cost Relationships

Input (Units)	Total Output (Units)	Average Product =Y/X (Units)	Marginal Product = ΔY/ΔX (Units)	Total Fixed Costs (TFC) (Rs)	Total Variable Cost (TVC) @ Rs.2/Unit	Total Cost= TFC+ TVC (Rs)	Average Fixed Cost (AFC) =TFC/Y	Average Variable Cost (AVC) = TVC/Y	Average Total Cost (ATC) = TC/Y	Marginal Cost (MC) =ΔTC/ΔY	Marginal Revenue (MR) =ΔTR/ΔY
0	0	0	0	10	0	10	0	0	0	-	-
1	2	2.00	2	10	2	12	5.00	1.00	6.00	1.00	2
2	5	2.50	3	10	4	14	2.00	0.80	2.80	0.67	2
3	9	3.00	4	10	6	16	1.11	0.67	1.78	0.50	2
4	14	3.50	5	10	8	18	0.71	0.57	1.28	0.40	2
5	19	3.80	5	10	10	20	0.53	0.53	1.06	0.40	2
6	23	3.83	4	10	12	22	0.43	0.52	0.95	0.50	2
7	26	3.71	3	10	14	24	0.38	0.54	0.92	0.67	2
8	28	3.50	2	10	16	26	0.36	0.57	0.93	1.00	2
9	29	3.22	1	10	18	28	0.34	0.62	0.96	2.00	2
10	29	2.90	0	10	20	30	0.34	0.69	1.03	-	2
11	28	2.55	-1	10	22	32	0.36	0.79	1.15	-	2
12	26	2.17	-2	10	24	34	0.38	0.92	1.30	-	2

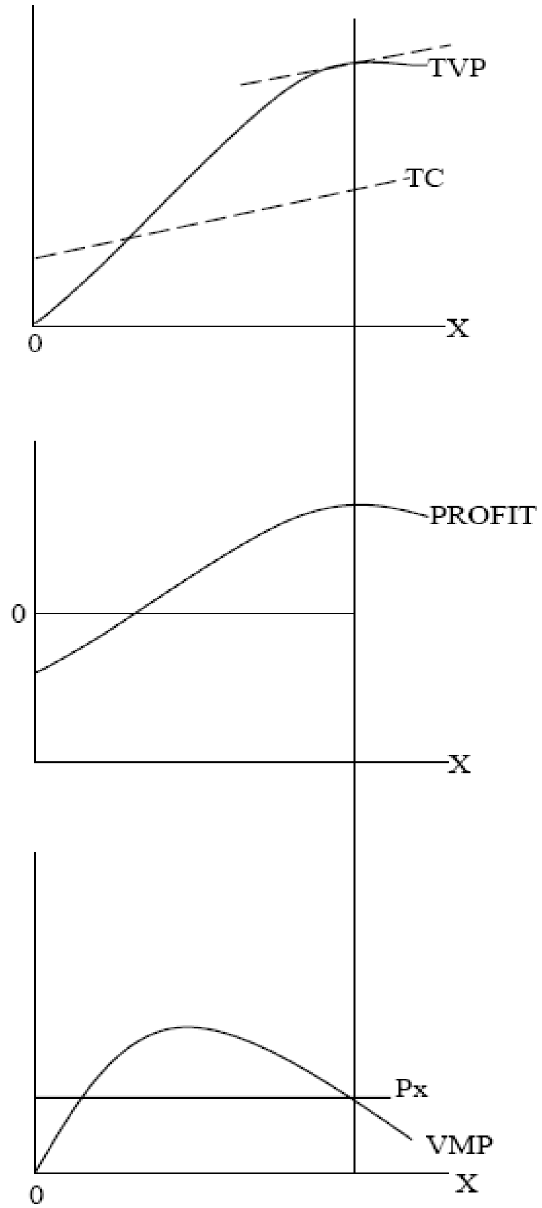


Fig.10.8 (a) Determining the Optimum Amounts of Input Using Total Value Product, Total Cost, Profit and Value of Marginal Product Curves.

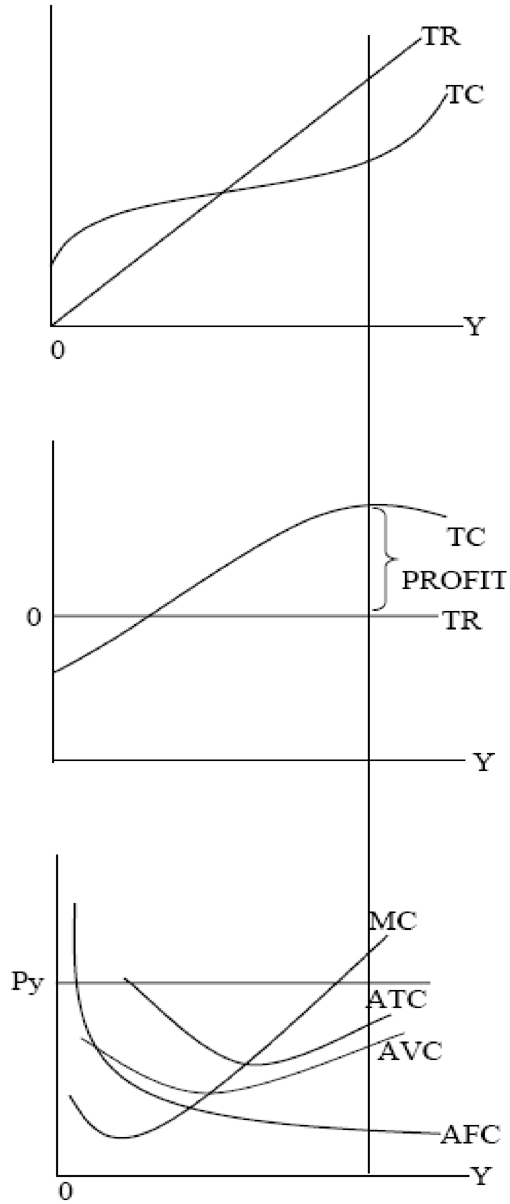


Fig. 10.8 (b) Determining the Optimum Amount of Output Using Cost and Revenue Curves

The expression, $Py.\Delta Y$ measures returns added by an increase in output while $Px.\Delta X$ measures the cost added by the increase in input. But from the output criterion, Py = MC, the same added cost and added return can be derived.

$$Py = MC = \frac{Px}{MPP} = Px \frac{\Delta X}{\Delta Y}$$

$$\mathbf{Py.\, \Delta Y = Px.\, \Delta X}$$

Thus, the two methods of determining the optimum levels are comparable.

Table 10.5 Response of Paddy to Nitrogen: Application of Profit Maximization Principle.

Variable Input (X)	**Output (Y)**	**Total Cost =TFC (Rs.10)+TVC @Rs.2/unit of input**	**Total Value Product =Py.Y @Rs.2/unit of output**	**Profit = TVP-TC**
0	0	10	0	-10
1	2	12	4	-8
2	5	14	10	-4
3	9	16	18	2
4	14	18	28	10
5	19	20	38	18
6	23	22	46	24
7	26	24	52	28
8	28	26	56	30
9	29	28	58	30
10	29	30	58	28
11	28	32	56	24
12	26	34	52	18

Lecture No.7. Economies of scale - external and internal economies and diseconomies - Returns to scale - Economies of size

e. Minimum Loss Principle

There can be two decision situations: 1) when selling price covers the average total cost and 2) when selling price is less than average total cost but more than average variable cost. In short run, only variable costs are important in decision-making. In short-run, if price falls below short-run average cost, the firm has no choice but to incur losses. The firm will shut down production, if price falls below average variable cost. So the minimum of average variable cost is the shut down point. This minimum price at which shutting down becomes the preferred alternative is the shut down price.

While production should be maintained in the short run if selling price is above variable cost, it cannot be continued indefinitely unless selling price exceeds average total costs. Unless all fixed costs are returned over long period, the farmer must either switch over to other occupations or experience a continuous decline in living standards. Thus, if the total returns are more than the total costs, the objective of the producer is to maximize the profit. If the MR is less than the ATC, but more than AVC, the objective of the producer is to minimize the loss in short run. When price of output is at P0, there is profit as the equilibrium (MC = MR) is above the minimum of ATC. When price is at P_2,

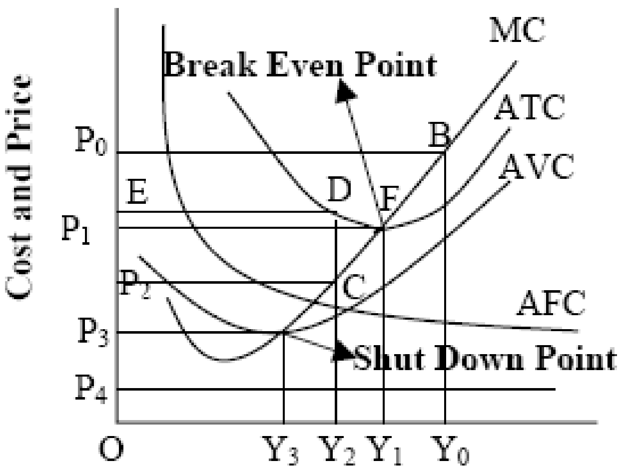


Fig.10.9 Break-Even and Shut Down Points

the loss in short run, is EP2 or CD or EP2CD. The price P3is the shut down price. When price of output is at P4, the farm would incur loss, as it does not cover even the minimum of AVC.

When price is at minimum of ATC (P_1), there is neither profit nor loss. Hence, minimum of ATC isthe break-even point where both fixed andvariable costs are covered.

f) Factor - Product Price Changes and Production Decisions

The decision-maker or farmer has to expect changes in optimum output, if either the price of output (Py) or the price of factor (Px) changes.

MC_2

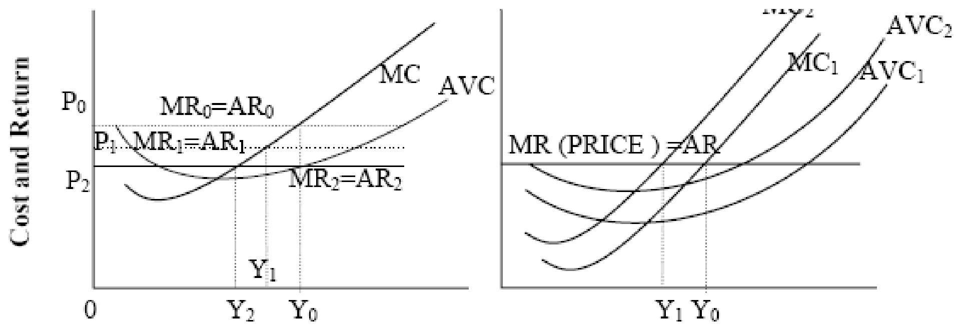


Fig.10.10 (a) Effect of Changes in Output Prices

Fig. 10.10 (b) Effect of Changes in Input Prices

1) Effect of changes in output prices: A decrease in product price would result in decrease of marginal revenue for each level of output. Thus, the optimum output level would decrease from Y_0 to Y_1, if output price decreases from P_0 to P_1 and this would indicate a direct relationship between product price and optimum output levels (Fig. 10.10 (a)).

2) Effect of changes in input prices: An increase in price of variable input causes the cost curves to move upward Fig. 10.10 (b). The intersection of MC_2 with MR will be at a lower output point and production will be reduced from Y_0 to Y_1 in order to maximize the profit. There is an inverse relationship between the factor price and optimum output, i.e., the optimum output level decreases if input price increases.

g) Importance of cost study: The cost study is useful: 1) to calculate profit or loss of an enterprise; 2) to determine the relative profitability of various enterprises; 3) to identify the causes for variations in the unit cost of production; 4) to determine the efficiency and intensity of input-use; and 5) to determine the optimum requirements of variable inputs for each enterprises.

i) Cost of Production and Cost of Cultivation: Cost of production is referred to the expenses incurred per unit of output whereas cost of cultivation is referred to the expenditure incurred per unit area. Cost of production for major crops is often discussed for government's policy formulation in price fixation. Moreover, farmers often lodge complaints on the ground that the price does not cover the cost of production. Hence, the need to study the cost components and cost of production of various crops is evident. Better understanding of various cost components would be useful to control and manage different cultivation practices.

ii) Cost Concepts: Some of the cost concepts used in farm management studies by the Commission on Agricultural Costs and Prices (CACP) of Government of India are A_1, A_2, B_1, B_2, C_1 and $C_{2,}$ which are defined as follows:

Cost A1 includes:

1. Value of human labour (casual and permanent).
2. Value of bullock power (owned and hired).
3. Value of machine power (owned and hired).
4. Value of seeds.
5. Value of manures and fertilizers.
6. Value of plant protection chemicals.
7. Value of weedicides.
8. Irrigation charges.
9. Land revenue and other taxes.
10. Depreciation on farm implement and farm buildings.
11. Interest on working capital.
12. Other miscellaneous expenses.

The following concepts can be used for easy calculation of the cost of cultivation.

1) Depreciation for buildings: 2 per cent for *pucca* building; 5 per cent for tiled building and 10 per cent for *katcha* building.

2) Depreciation for implements: 10 per cent for major implements and 20 per cent for minor implements.

3) Depreciation for cattle: Appreciation in the value of animals during the first 3 years would be at the ratio of 1:3:5.It remains constant during 4th and 5th year. Then it is assumed that the value of animal depreciates @ 12.5 per cent per year from 6th to 14th year in straight-line method.

4) Interest on working capital: 12 per cent per annum or opportunity cost of capital.

Cost A2 = Cost A1 + Rent paid for leased in land.

Cost B1 = Cost A1 + Interest on the value of owned capital assets (excluding land).

Interest rate of long - term government floated loans or securities: 10 per cent.

Cost B2 = Cost B1 + Rental value of owned land (less land revenue) and Rent paid for leased in land.

Cost C1 = Cost B1 + Imputed value of family labour.

Cost C2 = Cost B2 + Imputed value of family labour.

iii) Income measures in relation to different cost concepts

1. Farm Business Income = Gross Return - Cost A1.
2. Owned Farm Business Income = Gross Return - Cost A2.
3. Family Labour Income = Gross Return - Cost B2.
4. Net Income = Gross Return - Cost C2.

5. Farm Investment Income = Net Income + Imputed rental value of owned land + Interest on fixed capital.

iv) Opportunity Cost

Every resource used in the production process has but one true cost; its opportunity cost. The opportunity cost of a resource is the return, the resource can earn when put to its best alternative use. Suppose, a farmer applies fertilizer (50 kgs) to paddy will add Rs.500 and application of fertilizer (50 kgs) to sugarcane would add Rs.600. Now, if he fertilizes sugarcane, the opportunity cost of fertilizer is Rs.500; he has foregone Rs.500 to earn Rs.600. Every resource used in the production process, thus, has but one true cost; opportunity cost, the next best alternative foregone.

v) Economic Efficiency

Economic efficiency refers to the combinations of inputs that maximize an individual's objectives. Economic efficiency is defined in terms of two conditions, namely, necessary and sufficient.

a) Necessary condition: This condition is met in a production process where there is (1) no possibility of producing the same amount of product with fewer inputs (reducing one or more resources) and (2) no possibility of producing more product with the same amount of inputs. In production function analysis, this condition is met in stage II; that is, when the elasticity of production is equal to or greater than zero and is equal to or less than one ($0 \leq \varepsilon p \leq 1$). The necessary condition refers only to the physical relationship. It is universal because it is applicable in any economic system. No one would knowingly produce in stage III because the same or larger output could be obtained by moving to stage II with lesser input. In a given input-output relationship, many input-output combinations will satisfy the necessary condition. For this reason, an additional condition is needed to single out one alternative from the many that meet the necessary condition.

b) Sufficient Condition: Unlike the necessary condition, which is objective, the sufficient condition for efficiency encompasses individual or social goals and values. In abstract theory, the sufficient condition is often called a choice indicator. The choice indicator helps the manager determine input-use compatible with his objectives. The sufficient condition for an individual striving for high yields per acre will be different from that of an individual whose objective is maximization of profits per acre. In either of these cases, while the choice indicators satisfying the sufficient condition vary, economic efficiency is met because the manager is achieving his goals. Thus, the above elementary variations consider all the possible inter and intra planning period, rate of transformation, technical substitution and product transformation for the input-output, input-input and product-product relationships. The set of necessary and sufficient conditions for profit maximization, corresponding to the above three elementary operations is in Table 10.6 below:

Table 10.6 Necessary and Sufficient Conditions

Necessary condition	**Sufficient condition**
1. The marginal product of any factor with respect to any product must equal the ratio of their prices. $\frac{\Delta Y}{\Delta X} = \frac{Px}{Py}$	1.There must be a diminishing marginal product of a factor with respect to a product.
2. The rate of technical substitution between any two inputs must equal the ratio of their prices. $\frac{\Delta X_1}{\Delta X_2} = -\frac{Px_2}{Px_1}$	2.The rate of technical substitution between inputs must be diminishing (Iso quant is convex towards origin).
2. The rate of product transformation for every pair of products must equal the ratio of their prices: $\frac{\Delta Y_1}{\Delta Y_2} = -\frac{Py_2}{Py_1}$	3.The rate of transformation between products must be increasing (product transformation curve is concave towards origin).

vi) A Choice Indicator: A choice indicator is a yard stick or an index or a criterion indicating which of the two or more alternatives is optimum or will maximize a given objective or end. E.g. Price ratio, substitution ratio, etc. A product can be produced in many ways through different combinations of resources and techniques. The most desirable combination of products or factors cannot be determined without a choice indicator.

a) Optimum Input: P_y MPP = P_x (or) VMP = P_x

b) Optimum Output: P_y = MC

c) Least Cost Combination: $\frac{\Delta X_1}{\Delta X_2} = \frac{Px_2}{Px_1} = \frac{MPPx_2y}{MPPx_1y}$

d) Maximum Revenue Yielding Combination: $\frac{\Delta Y_1}{\Delta Y_2} = \frac{Py_2}{Py_1} = \frac{MPPxy_1}{MPPxy_2}$

A choice must be made with the help of an indicator listed above. It is usually expressed in monetary terms, but could be any other index that reflects likes and dislikes of the farmers. For example, while making a decision, a farmer might ask himself whether paddy is yielding the return twice as much or one-half as much as a competing crop, say irrigated ground-nut. In the study of production economics, the commonly assumed goal of the farm manager is economic efficiency, which would subsume the narrower goal of profit maximization.

Lecture No. 8

Factor - Factor relationship - Principle of substitution - isoquant, isocline

In factor-product relationship, we studied the situation where only one input is varied and all other variables are held constant. But in most real world situations, two or more inputs are often varied simultaneously. So a farmer must choose the particular combination of inputs which would minimize the cost for a given output level. Thus, the main objective here is minimization of cost at a given level of output. When two or more inputs are variables, a given amount of output may be produced in more than one way, i.e., there is a possibility of substituting one factor (X_1) for another (X_2) as product level (Y) is held constant. The objectives of factor-factor relationship are i) minimization of cost at a given level of output and ii) optimization of output to the fixed factors through alternative resource-use combinations. In this case, the production function is given by Y = (X_1, X_2 / X_3 ,...., Xn), i.e., the production depends on the amounts of X_1 and X_2 while the other inputs are held constant.

A. ISOQUANT (OR) ISO PRODUCT CURVE

An isoquant is defined as the locus of all combinations of inputs, X_1 and $X_{2,}$ for obtaining a given level of output, say, Y(0). Mathematically, such an isoquant is written as: $X_1 = f(X_2, Y(0))$ or $X_2 = f(X_1, Y(0))$. Some of the important types of isoquants depending upon the degree of substitutability between the inputs, are given in figures below:

i) Linear Isoquant: In this case, two inputs substitute at constant rates. Labour input supplied by different persons substitutes at a constant rate. Ammonium sulphate containing 20.6 per cent nitrogen and urea containing 46 per cent nitrogen would substitute for each other at a constant rate. The decision rule is simple, i.e., use either of the two factors of production depending on their relative prices. The rate at which one factor (X_1) is substituted for one unit increase in another factor (X_2) at a given level of output is called Marginal Rate of Substitution (MRS). The marginal rate of substitution of X_2 for X_1 is denoted by: 187

In linear isoquant, the rate at which these two inputs can be substituted at a given level of output is constant regardless of the level of the two inputs used.

$$MRS_{x2\,x1} = \frac{\Delta X_{11}}{\Delta X_{21}} = \frac{\Delta X_{12}}{\Delta X_{22}} = \ldots = \frac{\Delta X_{1n}}{\Delta X_{2}n}$$

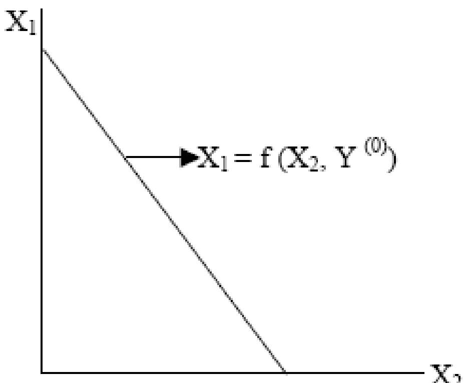


Fig.11.1 Linear Isoquant

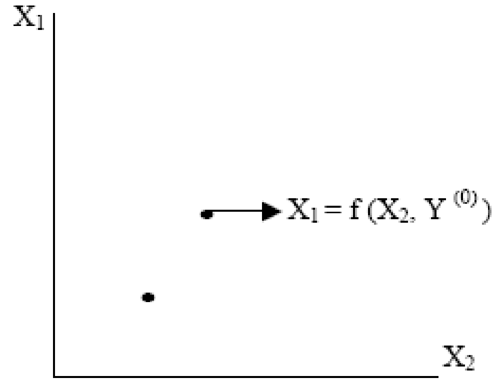


Fig.11.2 Inputs Combine in Fixed Proportion

ii) Fixed Proportion Combination of Inputs (Perfect Complements): Inputs that increase output only when combined in fixed proportions are called technical complements. Only one exact combination of inputs will produce the specified output. A tractor and a driver may serve as a fairly good example. Here, there is no economic problem in decision-making because there exists no alternative choice.

iii) Varying (Decreasing) Rate of Substitution: The amount of one input (X_1) required to be substituted for by one unit of another input (X_2) at a given level of production decreases. This is known as decreasing rate of substitution. Thus, decreasing rate of substitution means that every subsequent increase in the use of one factor replaces less and less of the other

Each point on the isoquant is the maximum output that can be achieved with the corresponding input combination. Isoquants are convex to the origin Fig.11.3. Two isoquants do not intersect each other.

iv) High contours represent higher output levels: Isoquant map indicates the shape of the production surface, which again indicates the nature of output response to the inputs. An isoquant which is far away from the origin represents higher level of output than an isoquant which is closer to the origin.

v) Marginal Rate of Input (Factor) substitutions (or) Rate of Technical Substitution (RTS): Marginal Rate of Substitution of X_2 for X_1 (MRS_{X2X1}) is defined as the amount by which X^1 must be decreased to maintain output at a

constant level when X^2 is increased by one unit. Between the two points (X_2 =2, X_1 =10) and X_2 =3, X_1 = 5), the MRS of X_2 for X_1 is,

The MRS is negative, because the isoquant slopes downward and to the right;

$$MRS_{x2\,x1} = \frac{\Delta X_1}{\Delta X_2} = \frac{5 - 10}{3 - 2} = \frac{-5}{1} = -5 .$$

that is, the isoquant has a negative slope.

Table 11.1 Decreasing Rate of Substitution

Variable Input (X_1)	Variable Input (X_2)	ΔX_1	ΔX_2	$MRS = \frac{\Delta X_1}{\Delta X_2}$
23	0	-	-	-
16	1	7	1	-7
10	2	6	1	-6
5	3	5	1	-5
1	4	4	1	-4
0	5	1	1	-1

vi) Isocost line: Isocost line determines all combinations of the two inputs that cost the same amount. Each point on the isocost line represents a combination of inputs that can be purchased with the same outlay of funds (Fig.11.4). Under constant price situation, each possible total outlay has a different isocost line. As total outlay increases, isocost line moves higher and higher and moves farther away from the origin. Changes in the input prices will change the slope of isocost line as the slope indicates the ratio of input prices. A decrease in the input price means that more of that input can be purchased with the same total variable cost; an increase means that less can be purchased.

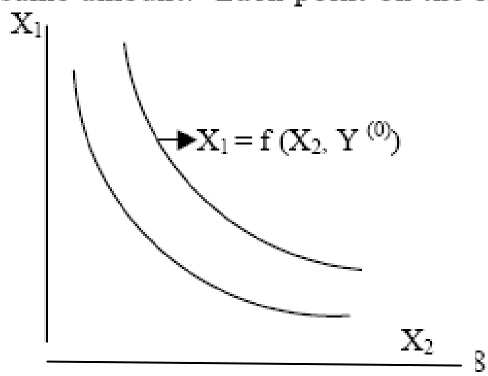


Fig.11.3 Convex Isoquant.

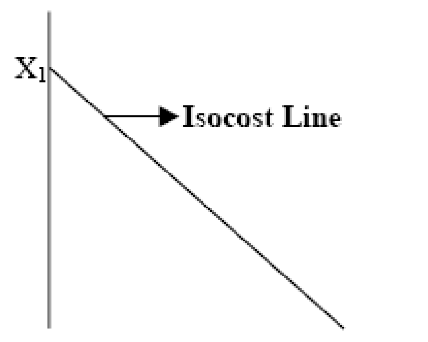


Fig.11.4 Isocost Line

Total Outlay = Rs.36; Price of X_1 = Rs. 4; Price of X_2 = Rs.3; When $X_1 = 0$, $X_2 = 12$; When $X_2 = 0$, $X_1 = 9$.

The equation of the isocost line can be found by solving the TVC equation

for X_1 as an explicit function of X_2. $Px_1X_1 = TVC - Px_2X_2$ and

$$X_1 = \frac{TVC}{Px_1} - \frac{Px_2}{Px_1} X_2$$

Lecture No.9

Expansion path, ridgeline and least cost combination of inputs

vii) Least cost combination: The problem here is to find out a combination of inputs, which should cost the least, i.e., minimization of cost. The tangency of isocost and isoquant would indicate the least cost combination of X_1 and X_2, i.e., slope of isoquant = slope of isocost. Least cost combination is given, algebraically, by equating

$$MRS_{x2\,x1} = \frac{\Delta X_1}{\Delta X_2} = -\frac{Px_2}{Px_1} \text{ ,i.e., } - Px_1(\Delta X_1) = Px_2(\Delta X_2)$$

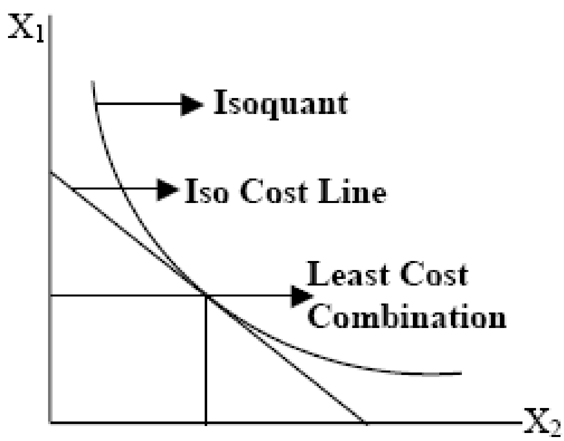


Fig.11.5 Least Cost Combination

If - Px_1 (ΔX_1) > Px_2 (ΔX_2), then, thecost of producing the given output amountcould be reduced by increasing X_2anddecreasing X_1because the cost of an addedunit of $X_2$is less than the cost of the unitsof X_1, it replaces. On the other hand, ifbetween two points of the isoquant,Px_1 (ΔX_1) < - Px_2 (ΔX_2), then the cost of producing the specified quantity of output can be reduced by using less X_2 and adding X_1The marginal physical product equations can be used to determine the returns per rupee spent at the least cost point. Rewriting the least cost combination as:

$$\frac{MPPx_1}{Px_1} = \frac{MPPx_2}{Px_2}$$

$$-\frac{\Delta X_1}{\Delta X_2} = \frac{dX_1}{dX_2} = \frac{MPPx_2}{MPPx_1} = \frac{Px_2}{Px_1}$$

$$Y = f(X_1, X_2)$$

Total differential is:

$$dY = \frac{\delta Y}{\delta X_1} dX_1 + \frac{\delta Y}{\delta X_2} dX_2 = 0$$

$$-\frac{dX_1}{dX_2} = \text{MRS (or) RTS} = \frac{(\delta Y/\delta X_2)}{(\delta Y/\delta X_1)} = -\frac{MPPx_2}{MPPx_1}$$

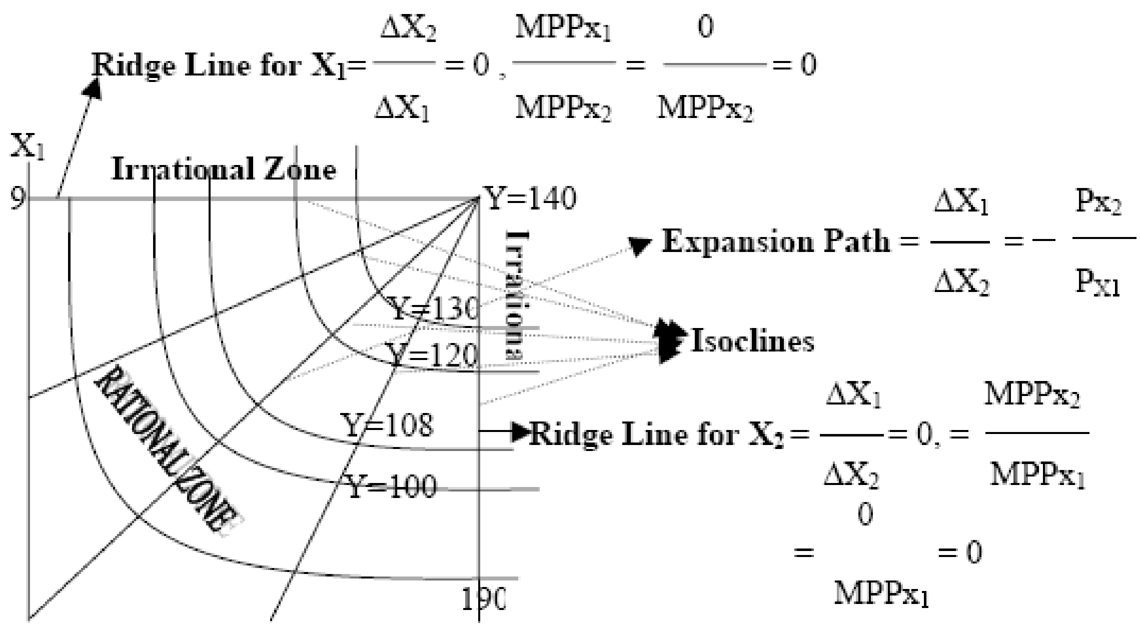
viii) Isoclines, Expansion Path and Profit Maximization: Isoclines are lines or curves that pass through points of equal marginal rates of substitution on an isoquant map. That is, a particular isocline will pass through all isoquants at

points where the isoquants have a specified slope. There are as many different isoclines as there are different slopes or marginal rates of substitution on an isoquant. The expansion path is also an isocline that connects the least cost combinations of inputs for all yield levels. On expansion path, the marginal rate of substitution must equal the input price ratio:

$$\textbf{Expansion Path } (\textbf{MRS}_{X2X1}) = \frac{\Delta X_1}{\Delta X_2} = -\frac{Px_2}{P_{X1}}$$

Ridge lines represent the limits of the economic relevance, the boundaries beyond which the isocline and isoquant maps have no economic meaning. The horizontal ridge line represents the points where $MPPx_1$ is zero and the vertical line represents the points where $MPPx_2$ is zero.

On the ridge line for X_1, MPP_{X1} is zero, and tangent to the isoquant which is vertical having no defined slope. On the ridge line for X_2, MPP_{X2} is zero and the isoquant has a zero slope and thus MRS = 0. Ridge lines are so named



Y= 45

Fig. 11.6 Isoclines and Expansion P.... 7

The slope of the isoquant was shown to be: MRS of X_2 for $X_1 = - \frac{MPPx_2}{MPPx_1}$

because they trace the high points up the side of the production surface, much like mountain ridges that rise to the peak of the mountain. Ridge lines represent the points of maximum output from each input, given a fixed amount of the other input. When $X_1 = 1$, output can be increased by adding X_2 upto the amount devoted by the ridge line (7 units). At that point, output from X_2 is a maximum given one unit of X_1 and MPP $_{X2}$ is zero. Past $X_2 = 7$, MPP $_{X2}$ is negative while MPP X_1 is positive; the inputs have an opposite effect on output and are no longer substitutes. Thus, the ridge lines denote the limits of substitution. Outside

the ridge lines, the inputs do not substitute in an economically meaningful way. Output is maximum (140) where the ridge lines, and all other isoclines, converge. For 140 units of output, the least cost and only possible combination is 9 units of X_1 and 7 units of $X_{2.}$

ix) Expansion Path and Profit Maximization

The expansion path traces out the least cost combination of inputs for every possible output level. The question now arises; which output level is the most profitable? Conceptually, this question is answered by proceeding out the expansion path that is increasing output until the value of the product added by increasing the two inputs along the expansion path is equal to the combined cost of the added amount of two inputs. Viewed from the input side, this is same as saying that the VMP of each input must equal the unit price of that input; viewed from the output side, it is the same as saying the marginal cost must equal marginal revenue. Thus, while all points on an expansion path represent least cost combinations, only one point represents the maximum output level. For one output and two variable inputs, the equation is:

Profit = Py Y - $Px_1 X_1$ - $Px_2 X_2$ – TFC.

Maximizing this function with respect to the variable inputs gives two equations in two unknowns.

The above two equations can be written as: $VMPx_1 = Px_1$ (or) $VMPx_2 = Px_2$. Thus, the profit-maximizing criterion requires that the marginal earnings of each input must be equal to its cost

$$Y = 18X_1 - X_1^2 + 14X_2 - X_2^2$$

The marginal physical products of X_1 and X_2 are multiplied by Py = Rs. 0.65. Then, $VMPx_1 = (18 - 2X_1)\ 0.65$; $VMPx_2 = (14 - 2X_2)\ 0.65$

Equating VMP's with the input prices of Rs.9 and Rs.7 for X_1 and X_2 respectively, we get, $(18 - 2X_1)\ 0.65 = 9$; $(14 - 2X_2)\ 0.65 = 7$

The solutions are 2.08 for X_1 and 1.6 for X_2. Substituting these values in the production function predicts a value of Y equal to 53 units.

Then, Profit = 0.65 (53) - 9 (2.08) - 7 (1.60) - TFC= Rs. 4.53 - TFC

The optimum criterion for two variable inputs is often expressed as:

$$\frac{VMPx_1}{Px_1} = 1\ ; \frac{VMPx_2}{Px_2} = 1 \text{ or because both equal 1, } \frac{VMPx1}{Px_1} = \frac{VMPx2}{Px_2} = 1$$

All variable inputs must be earning as much as they cost on the margin. Rewriting in a different form, yields :

$$MPPx_1 = \frac{Px_1}{Py}\ ; \frac{MPPx_1}{Px_1} = \frac{1}{Py} = \frac{1}{MC}, \text{ Since } Py = MC$$

$$MPPx_{2z} = \frac{Px_2}{Py}\ ; \frac{MPPx_2}{Px_2} = \frac{1}{Py} = \frac{1}{MC}$$

The above expression is the same as MR = MC under perfect competition.

B. ECONOMIES OF SCALE

The scale of production influences the cost of production. In general, larger the scale of production, the lower is the average cost of production. The term 'economies' means 'advantages' and the term 'scale', here, means 'large-scale production'. Thus, economies of scale refer to the advantages of large-scale production. Economies of scale can be categorized into i) internal economies and (ii) external economies of scale.

i) Internal Economies

Internal economies are those economies in production (those reductions in production costs), which occur in the farm (firm) itself when it expands its output or enlarges its scale of production. Internal economics are those advantages that are exclusively available to a particular firm, as a result of its own expansion in the scale of production. The internal economies are dependent on the resources of the individual house of business, on their organization and the efficiency of their management. Internal economies are of the following five

types: a) Technical economies, b) Managerial economies, c) Marketing economies, d) Financial Economies, and e) Risk bearing economies.

a) Technical Economies: A large-scale production unit can use large and modern or sophisticated machines so as to reduce production costs. A large establishment can prevent wastage by utilizing the by-products efficiently. Latest technologies can be used in larger units to reduce the cost of production (E.g.) A big vegetable oil mill can have a cattle feed industry and a big dairy unit.

b) Managerial Economies: These economies arise from the creation of special (separate) departments for different functions like production, maintenance, purchase, sales etc. In a small factory, a manager is a worker, organizer and salesman. Much of his time is wasted on things of little economic importance. In a big concern, such jobs can be allotted to junior employees and the manager can concentrate on jobs which bring more profits. Such kind of division of labour is possible in large units. Thus, the job can be done more efficiently and more economically in large units.

c) Marketing Economies: They arise from the purchase of materials and sale of goods. Large business firms have better bargaining advantages and are provided with a preferential treatment by the firms they deal with. They are able to secure freight concessions from railways and road transport firms, prompt delivery and careful attention from all dealers. A large firm can employ expert purchase managers and sales managers. In selling, it can cut down selling costs and in purchasing, it can have a wider choice.

d) Financial Economies: A big firm has better credit facilities and can borrow on more favourable terms. It encourages prospective investors with incentives and higher returns and therefore, its shares have a wider market. A big firm can issue its shares and debentures more easily than an unknown small firm.

e) Risk-Bearing Economies: A big firm can spread risks and can often eliminate them. It can diversify the output. It can also establish wider marketing net work for its products. If demand for any one of its products slackens in any one market, it may increase it in other markets. Thus, it can reduce the risk of fluctuations in the demand for its product.

ii) External Economies

External economies are those economies, which are available to each member firm as a result of the expansion of the industry as a whole. Expansion of industry may lead to the availability of new and cheaper raw materials, machineries and to the use of superior technical knowledge. External economies are advantages available to all the firms. For instance, construction of a new railway line benefits all firms set up in that locality and not to any particular firm alone. Various types of external economies are given below:

a) Economies of concentration: These economies arise from the availability of skilled workers, the provision of better transport and credit facilities, benefits from subsidiary units and so on.

Scattered firms cannot enjoy such economies. Concentration of firms enables the transport system to reduce the cost.

b) Economies of Information: All big-sized units can join together to publish trade journals and also to set up research and development facilities, which would benefit all firms.

c) Economies of Disintegration: When an industry grows, it becomes possible to split up some of the processes which are taken up by specialist firms. This may be beneficial to all the firms.

iii) Diseconomies of Scale

Large-scale production also has some disadvantages, which are known as diseconomies of scale. They are as follows: a) If the growth of the firm expands beyond the optimum limit, it will become unwieldy. As a result, the management becomes inefficient. (b) There may be frequent breakdown of machines due to poor maintenance. (c) There may be indiscipline among labourers and this would result in frequent strikes and lock outs. (d) Some times the over production exceeds demand and causes depression and unemployment. (e) The average cost of production will be more.

C. ECONOMIES OF SIZE

A study on economies of size would be useful to assess the optimum size of the plant. The collection of all durable assets owned by a farm is called the plant and this term, therefore, includes land, machinery, buildings and other durable assets found on farms. An increase in any one of these durable assets would increase plant size. The long run average cost curve has the same shape as the short run ATC curve. (But, long run cost has no fixed cost). When the firm is small, expansion of output usually increases efficiency, and average costs per unit of output will fall. The reasons for this decrease include specialization of labour and capital.

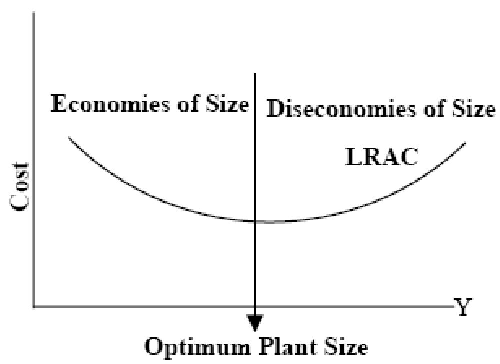


Fig.11.7 Economies of Size

As the size of the businessincreases, the manager may be ableto purchase inputs at a discount,thereby gaining market economies.Expansion of the firm enablesworkers to specialize and use moreadvanced or efficient technologies.Eventually, the long-run averagecurve will turn up; costs per unit ofoutput begin to increase as output isexpanded. As firm size increases, the manager encounters increasing difficulty in maintaining control of his organization, communications and coordination become more difficult, mistakes are both more frequent and more costly. As a result, costs rise. When LRAC are falling, the firm is experiencing economies of size. The minimum point on the LRAC curve indicates the optimum plant size. A plant of this size will produce the product at the lowest possible cost. Diseconomies of size occur where the LRAC curve is rising.

i) Relationship between Long run and Short-run Cost Curves

In the short - run, the farmer has a fixed plant-the number of acres, the buildings and the size and type of equipment are all fixed in amount. He can

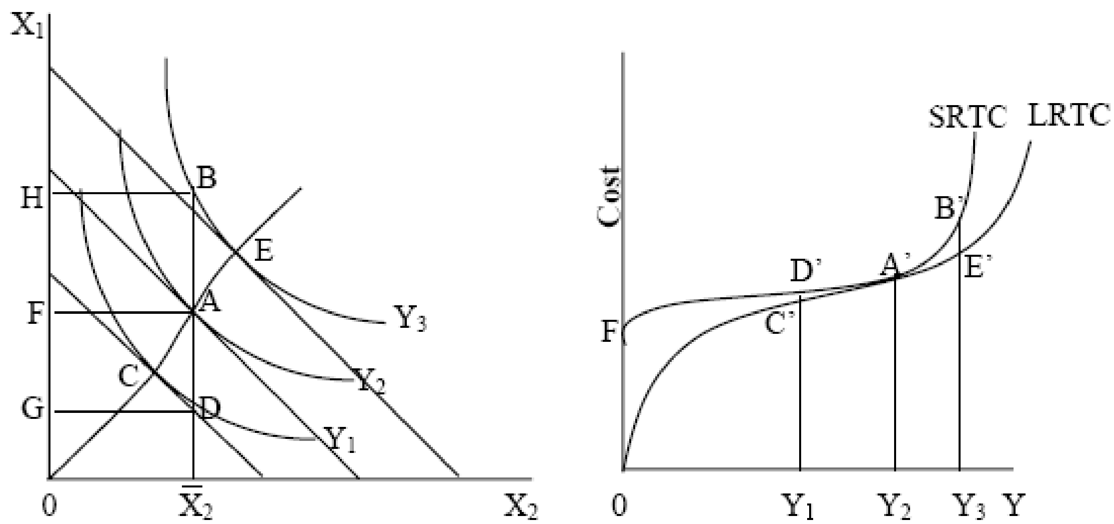


Fig 11.8 (a) *Fig.11.8 (b)*

Relationship between Short-Run and Long-Run Cost Curves

expand output in the short run only by changing the amount of variable input. This situation is depicted in Fig.11.8 (a). Plant size is fixed in the short run at X_2. That particular plant size, X_2 will produce output Y2 at the least average total cost when combined with OF amount of X1, the variable input. To produce outputs other than Y2 in the short run, the manager must vary the amount of X1 and by so doing, restrict input use to the combinations represented by the vertical line above X_2. For example, to produce output Y1 in the short run, the manager would use OG of X1 with the fixed plant, X_2 and to produce output Y3 in the short run the manager would use OH of X1 with X_2.

The combination of inputs at point A represents the least cost combination for the production of Y_2 in the long run, as do the combinations of by C for Y_1 and E for Y_3. Thus, the combination of inputs at D, OG of X_1 and X_2, necessarily costs more than the combination of inputs at point C on the long-run expansion path. Similarly, the combination at point B costs more than the combination at E. As a result, total costs in the short run along the line DAB will be higher than total costs in the long-run along the segment CAE on the long-run expansion path. The exception will occur at point A, where short-run and long - run costs will be equal.

This argument is also indicated in Fig. 11.8 (b). Fixed costs of amount OF are associated with X_2 amount of X_2. There are no fixed costs in the long-run. Short-run total costs, SRTC, increase with output but remain above long-run total costs, LRTC, until output Y_2 is reached. Point A' on LRTC and SRTC represents the cost of input combination at A in Fig.11.8 (a). At A' the two cost curves are tangent. At output levels greater than Y_2, SRTC increases more rapidly than LRTC. The costs of the input combinations C, D, E and B in

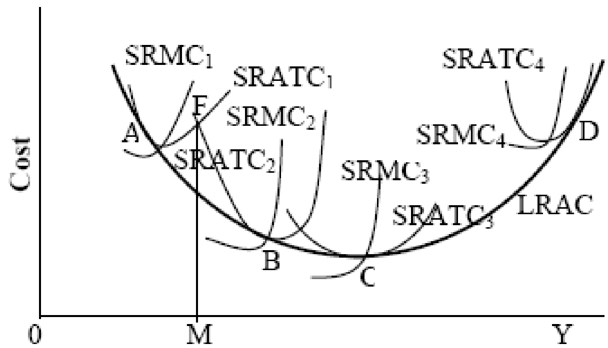


Fig.11.9 Long-Run Average Cost for Several Plan Sizes

Fig.11.8 (a) are represented by C', D',E' and B' in Fig.11.8 (b). In Figure11.9, the relationship between long-runaverage cost curve and several plantsizes is shown. $SRATC_1$ and $SRMC_1$ are the average and marginal costs forplant size 1. $SRMC^2$ and $SRATC^2$ arethe marginal and average costs for alarger plant size, plant size 2. Eachplant size represents a set of durable

inputs fixed at a certain level. Many plant sizes exist between 1 and 2, but to avoid clutter, their cost curves are not shown. Plant size 2 produces all outputs larger than (to the right of) the amount OM more efficiently than does plant size 1. As output increases further, plant size 3 becomes more efficient than 2. For plant sizes larger than 3, expansion of output is obtained only at increased cost per unit. As explained, the LRAC will be tangent to each of the SRAC curves. Because of this, the LRAC is called *Envelope Curve*. To the left of C, the LRAC curve is tangent to short - run curves to the left of the latter's minimum. At C, both long-run and short-run costs attain a minimum. Therefore, plant 3 represents the optimum plant size. To the right of C, LRAC is tangent to the short-run curves to the right of the latter's minimum.

The LRAC curve depicts the minimum average cost for each output level and thereby determines the most efficient plant size for each output level. Plant size 1 is most efficient in the production of the output corresponding to A, plant size 2 for B, plant size 3 for C, etc. Thus, the LRAC is the *envelope curve* that is tangent to each SRATC curve at the output for which that plant size is most efficient in the long-run.

D. RETURNS TO SCALE

Returns to scale measures the change in output resulting form a proportionate change in all inputs. It describes the technical economies of scale and is a long-run concept, when none of the inputs is fixed. Returns to scale in increasing, constant or decreasing depending on whether a proportionate increase in all the inputs increases the output by a greater, same or smaller proportion. If the proportionate change in output is lesser than the proportionate change in inputs, diseconomies of scale result. If the change in output is equal to the proportionate change in inputs, constant returns to scale exist. If the change in output is greater than the proportionate change in inputs, economies of scale exist. This concept can be expressed with an homogeneous production function $Y = f(X_1, X_2, ..., Xm)$ where, Y is output and $X_1, X_2, ..., Xm$ are inputs used in the production process. Let K denote the amount by which each input will be changed (1<K), i.e., K is any positive real number. The returns to scale will be defined by n where,

$$YK^n = f(KX_1, KX_2, . . . , KXm)$$

The factor Kn represents the change in output when all inputs are changed by the factor K. For example, if n equals one, the change in output is equal to the changes in the inputs and the returns to scale are constant. If n is greater than one, the change in output exceeds the proportionate change in all the inputs and returns to scale are increasing. Conversely, if n is less than one, the returns to scale are decreasing. In case of constant returns to scale, the distance between successive isoquants is constant, i.e., AB=BC=CD (Fig. 11.10 (a)). The distance goes on widening between isoquants when diminishing returns operate, i.e., AB<BC<CD (Fig.11.10 (b)). Finally, in case of increasing returns to scale, the distance between the successive isoquants becomes smaller and smaller as we move away from the origin on the isoquant map i.e., AB>BC>CD (Fig.11.10 (c)).

Returns to scale must be measured along a scale line, that is a straight line, passing through the origin. Proportionate input changes are possible only on such a line or ray. Thus, economies (diseconomies) of size are the same as economies (diseconomies) of scale only when the long long-run expansion path is a straight line passing through the origin. In most agricultural production situations, input proportions representing least cost combinations vary with the level of output. Therefore, strict interpretations of scale concepts are probably not of great value in agriculture.

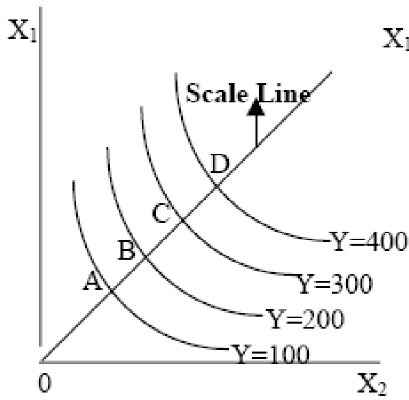


Fig.11.10 (a) Constant Return to Scale

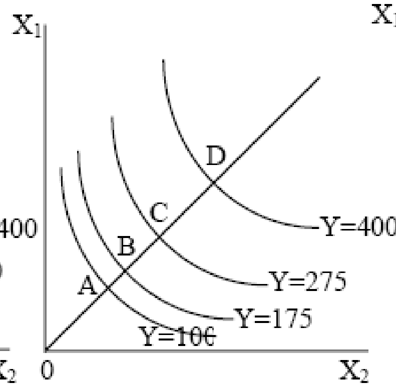


Fig.11.10 (b) Decreasing Return to Scale

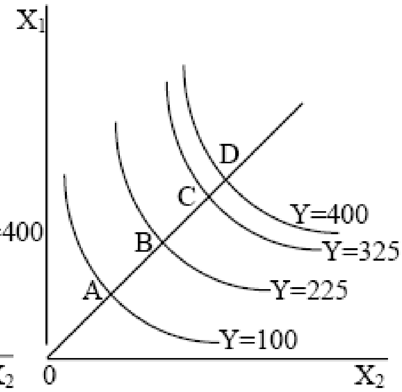


Fig.11.10 (c) Increasing Return to Scale

E. ELASTICITY OF FACTOR SUBSTITUTION

In the factor-factor relationship, the elasticity of factor substitution is defined as the percentage change in one input, X_1, in response to the percentage change in other input, X_2. Thus,

$$Es = \frac{\left\{\frac{\Delta X_1}{X_1}\right\}}{\frac{\Delta X_2}{X_2}} = \frac{\Delta X_1 X_2}{\Delta X_2 X_1} = (\text{MRS of } X_2 \text{ for } X_1)\left\{\frac{X_2}{X_1}\right\}$$

Elasticity of factor substitution is negative for inputs that are technical substitutes because the slopes of isoquants are negative; as one input increases, the other input decreases on the same isoquant. Elasticity of substitution for inputs that are technical complements is zero because MRS is zero. The elasticity of substitution measures and indicates the rate at which the slope of an isoquant changes. This is useful because it is expressed independent of unit of measurement.

Problem: Nitrogenous and Phosphorus fertilizer combination necessary to produce 2000 kgs of paddy is given in the following table. It shows how and to what extent nitrogen could be substituted for phosphorus fertilizer.

Table 11.2 Nitrogen and Phosphorus combinations Necessary to Produce Two Tonnes of Paddy

Combination Number	Nitrogen (X_1)(Kgs)	ΔX_1	Phosphorus (X_2)(Kgs)	ΔX_2	MRS of X_2 for X_1 $=(\Delta X_1 / \Delta X_2)$
1	52	-	11	-	-
2	44	- 8	12	1	- 8.00
3	38	- 6	14	2	- 3.00
4	33*	- 5	18*	4	- 1.25
5	30	- 3	23	5	- 0.60
6	28	- 2	29	6	- 0.33

(*Least cost combination of X_1 and X_2 inputs. If Px_1 and Px_2 are Rs. 6 and Rs.7.50 per kg respectively, the price ratio would be Px_2 / Px_1 = 7.50 / 6.00= 1.25). Thus, as shown in the table, we find that it is from combination 4, the least cost combination of 33 kgs of N and 18 kgs of P_2O_5 can be obtained, because it is at this point, the price ratio is equal to MRS or RTS, i.e.,

$$-\frac{\Delta X_1}{\Delta X_2} = \frac{Px_2}{Px_1}$$

Lecture No.10.

Product - Product relationship - types. Production possibility curve, iso revenue line and optimum combination of outputs

In this section, instead of considering the allocation of inputs to an enterprise or among enterprises, we discuss enterprise combinations or product- mix involving product-product relationships. We deal with what combination of enterprises should be produced from a given level of fixed and variable inputs.

A. PRODUCTION POSSIBILITY CURVE (ISO-RESOURCE CURVE) 200

The production possibility curve or product transformation curve is the locus of maximum amounts of two products, say Y_1 and Y_2, that can be produced from a given quantity of resources ($X^{(0)}$). Mathematically, such product transformation curve is represented by: $Y_1 = f(Y_2, X^{(0)})$ or $Y_2 = f(Y_1, X^{(0)})$. The Rate of Product Transformation (RPT) (or) Marginal Rate Product Substitution (MRPS)

between two products, Y_1 and Y_2, is given by the negative slope of this curve. The RPT of Y_2 for Y_1 can either be expressed as:

dY_1 / dY_2, the slope of the product transformation curve can be defined as the change (increase or decrease) in the level of Y_1 that must be accompanied by a unit change (decrease or increase) in the product (Y_2) at a given level of resource.

i) Relationship among Products: The basic product relationships can be: joint, complementary, supplementary and competitiveness.

a) Joint Products: Products, which result from the same production process, are termed joint products. In the extreme case, two products are combined in fixed proportions and the production of one without the other is impossible. E.g. Grain and straw. Production possibility curves for joint products of this type are presented in Figure 12.1 (a). No substitution is possible in this case. However, for example, different varieties of paddy produce varying proportions of straw and grain. Thus, the proportions may be changed by technologies or cropping practices usually associated with the fixed inputs. For such products, a narrow range of product substitution may exist as presented in Figure12.1 (b).

b) Competitive Products: Products are termed competitive when the output of one product can be increased only by reducing the output of the other product. Outputs are competitive because they require the same inputs at the same time. E.g. the manager can expand production of one output only by divert inputs-land, labour, capital and management-from one enterprise to another.

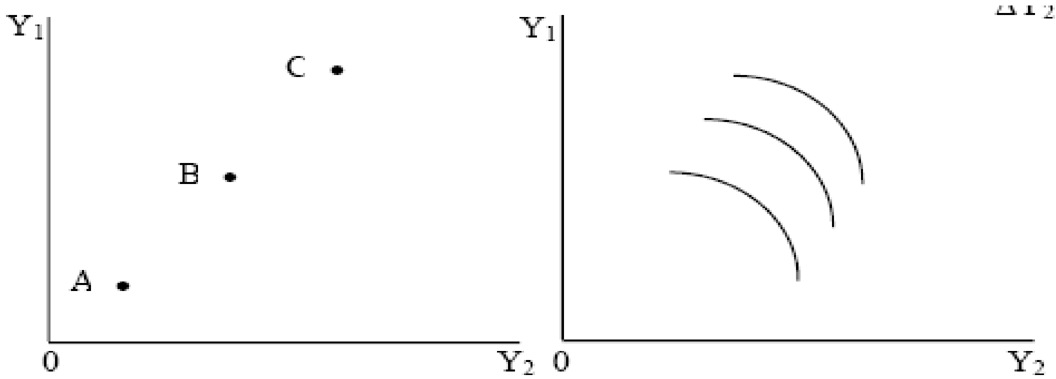


Fig.12.1 (a) *Joint Products* *Fig.12.1 (b)*

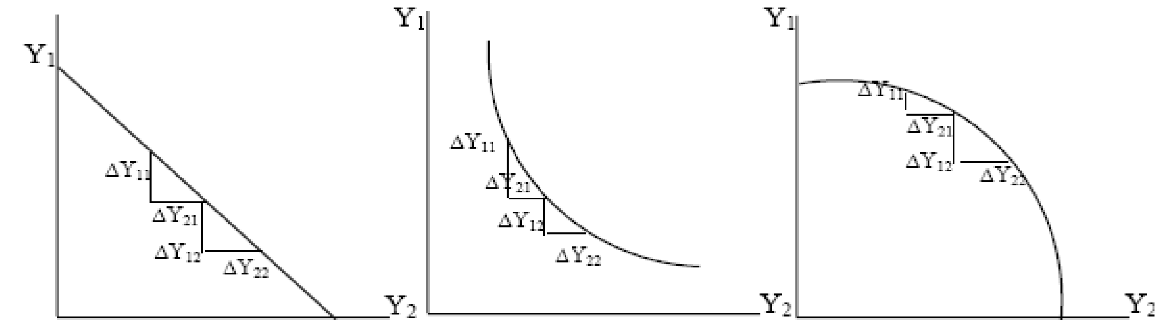


Fig.12.2(a)Constant RPT$_{Y2Y1}$ *Fig.12.2(b)Decreasing RPT*$_{Y2Y1}$ *Fig.12.2(c)Increasing RPT*$_{Y21}$

$$\frac{\Delta Y_{11}}{\Delta Y_{21}} = \frac{\Delta Y_{12}}{\Delta Y_{22}} = \ldots = \frac{\Delta Y_{1n}}{\Delta Y_{2n}} \qquad \frac{\Delta Y_{11}}{\Delta Y_{21}} > \frac{\Delta Y_{12}}{\Delta Y_{22}} > \ldots > \frac{\Delta Y_{1n}}{\Delta Y_{2n}} \qquad \frac{\Delta Y_{11}}{\Delta Y_{21}} < \frac{\Delta Y_{12}}{\Delta Y_{22}} < \ldots < \frac{\Delta Y_{1n}}{\Delta Y_{2n}}$$

When the production possibility curve has a negative slope, the products concerned are competitive. Two competitive products can substitute each other either at a constant or increasing or decreasing rate. Substitution of one product for another product at a constant rate is only a short-run phenomenon because such a relationship may not hold for long. Two varieties of any crop with all inputs held constant, during any single season provide an example of this type of substitution. Economic decision-making is easy in this case, i.e., the farmer would produce only one of these products depending upon yields and prices. Whenever a decreasing RPT exists between two products, every unit addition of one product, say Y_2 replaces less and less of other product, Y_1.The product transformation curve is concave away from origin and convex toward the origin. This type of relationship is quite rare. This type of decreasing RPT can be found in very small farms where capital is very limited and the produce of none of the two competitive commodities can be extended beyond the first stage of production. Decision-making is simple in this case, i.e., the farmer would produce only one of the two products depending on relative yields and prices. An increasing rate of product transformation between two products occurs when both products are produced in the stage of decreasing returns. The product transformation curve is concave towards the origin, i.e., increasing amounts of Y_1 must be sacrificed for each successive gain of one unit of other product, Y_2 for a given level of input.

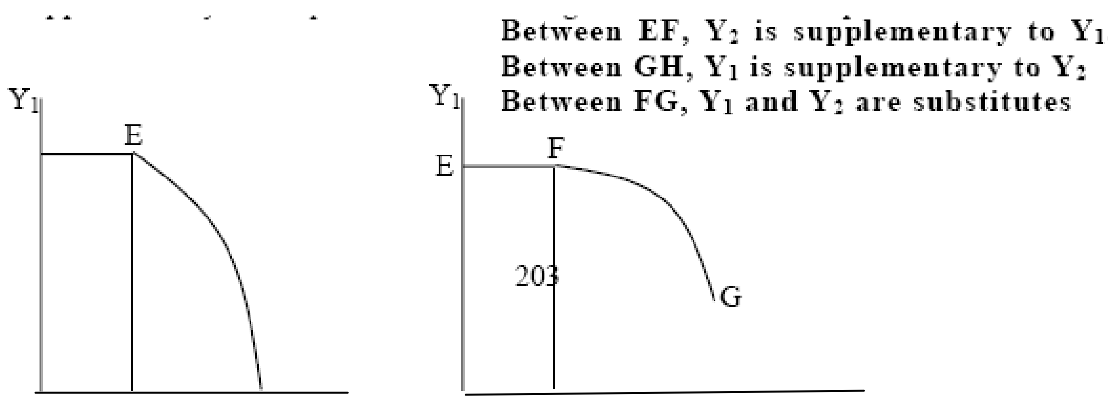
c) Complementary Products: Two products are complementary, if an increase in one product causes an increase in the second product, when the total amount of inputs used on the two are held constant.

Complementary usually occurs when one of the products produces an input used by the other product. An example of this is the use of a legume in rotation with cash crop. The legume may add nitrogen and improve soil structure or tilth and improve weed and insect control. These factors, in turn, serve as "inputs" for cash crops thus causing, over a period of time required by the rotation, an increase in the production of cash crop. The complementary products may eventually become competitive. For example, while one year of alfalfa in a four-year rotation may be complementary, two, three or four years of alfalfa could be produced only by successive reductions in the cash crops.

$$MRPS = \frac{\Delta Y_1}{\Delta Y_2} > 0.$$

d) Supplementary Products: Two products are called supplementary, if the amount of one can be increased without increasing or decreasing the amount of the other. In figure 12.4 (a) Y_2 is supplementary to Y_1. Y_2 can be increased from zero to OH amount without affecting the amount of Y_1 produced. Beyond E, the two outputs become competitive. In Fig.12.4 (b), each enterprise is supplementary to the other and competitive between FG.

Supplementary enterprises arise through time or when surplus resources are



Supplementry Products

available at a given point of time. Once purchased, a tractor is available for use throughout the year. Its use in one month does not prevent its use in another month. Thus, a tractor purchased to plough and plant may be put to a lesser use during the off-season. If two crops were harvested at the same time, however, the relationship would be competitive-use on one could reduce the amount of use on the other.

The supplementary relationship between products depends upon amount of use left in the resource. If the harvester is completely worn out harvesting corn in June, it will not be available for use in July. Milk cows and family gardens represent supplementary enterprises on some farms. In each case, labour or some other input is available for use on a small scale and rather than let it go idle, a small enterprise is undertaken.

$$\text{MRPS of } Y_2 \text{ for } Y_1 = \frac{\Delta Y_1}{\Delta Y_2} = 0$$

Production possibility curve is also known as opportunity curve as it presents all possible production opportunities.

ii) Marginal Rate of Product Substitution or Rate of Product Transformation: RPT is nothing but the slope of production possibility or opportunity curve.

$$\text{MRPS of } Y_2 \text{ for } Y_1 = \frac{\Delta Y_1}{\Delta Y_2}$$

The marginal rate of product substitution means the rate of change in quantity of one output (Y_1) as a result of unit increase in the other output (Y_2), given that the amount of the input used remains constant. As the amount of Y_2 produced increases, the amount of Y_1 sacrificed steadily increases. This is due to the decreasing marginal physical products displayed by the production functions.

iii) Iso Revenue Line: It is the line which defines all possible combinations of two commodities which would yield an equal revenue or income. Iso revenue line indicates the ratio of prices for two competing products. The point on Y_2 axis is always equal to TR/PY_2 while the point on the Y_1 axis equal TR/PY_1. The distance of the Iso revenue line from the origin is determined by the magnitude of the total revenue. As total revenue increases, the iso revenue line moves away from the origin. The slope of the iso revenue line is determined by the output prices.

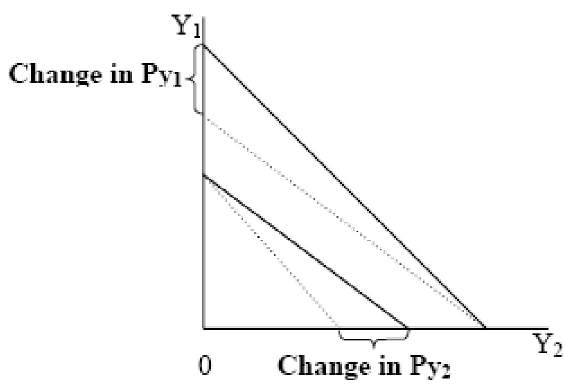


Fig.12.5 Iso Revenue Line

Thus, the output prices ratio is the slope of the iso revenue line. The negative sign means that the iso revenue line slopes downward to the right. The iso revenue lines are used for revenue optimization, while iso cost lines are used for cost minimization.

iv) Revenue Maximizing Combination of Outputs

The maximum revenue combination of outputs on the production possibility

erion.
MRPS of Y_2 for $Y_1 = \frac{\Delta Y_1}{\Delta Y_2} = - \frac{Py_2}{Py_1}$

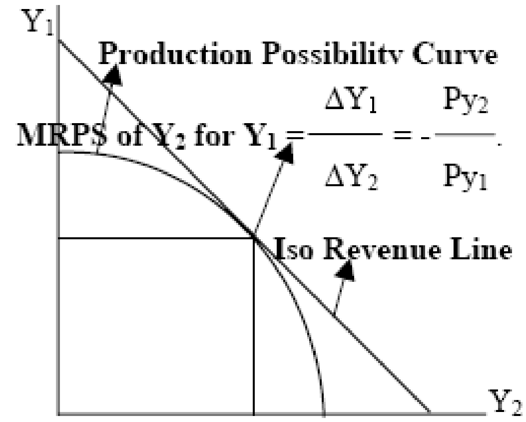


Fig.12.6 Maximum Revenue Yielding Combination

This can be rewritten as follows:

$Py_1(\Delta Y_1) = - Py_2(\Delta Y_2)$. This criterionstates that at the maximum revenue point,the increase in revenue due to adding aminute quantity of Y_2 is exactly equal tothe decrease in revenue caused by thereduction in Y_1. Thus, there is no incentiveto change the output combination. When$Py_1 (\Delta Y_1) > - Py_2 (\Delta Y_2)$, the amount of Y_2 should be decreased in favour of Y_1. When $Py_1 (\Delta Y_1) < - Py_2 (\Delta Y_2)$, then Y_2 should be increased at the expense of Y_1. As could be seen in the Figure 12.7, the line connecting maximum revenue points is called output expansion path. For each level of input, the maximum revenue combination of outputs will fall on the expansion path.

Lecture No 11.

Equi-marginal returns and Opportunity cost - comparative advantage

v) Opportunity cost and Marginal criterion for Resource Allocation: Maximum revenue from a limited amount of input was shown to occur when,

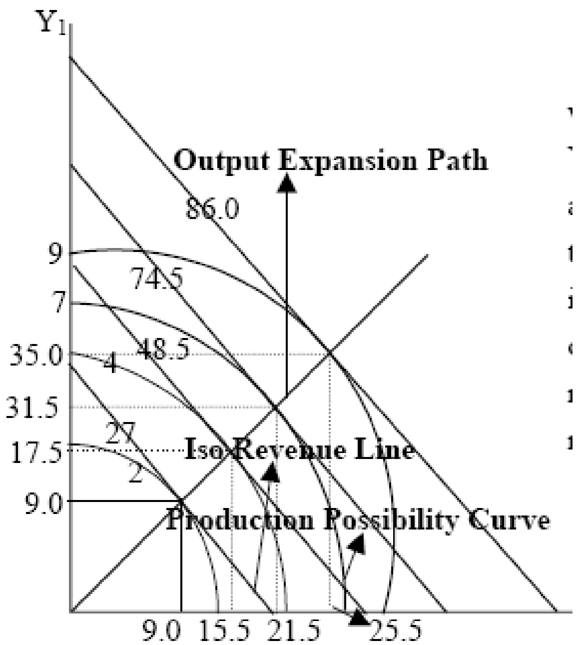


Fig.12.7 Output Expansion Path

where ΔY_1 isnegative. But the decrease inY_1could only be caused by shifting someamount of input, X, from enterprise (Y_1)to enterprise Y_2. Denote the amount ofinput shifted by 'ΔX'. Dividing both sidesof the above expression by ΔX andmultiplying both sides of the equality byminus

$$Py_2 \frac{\Delta Y_2}{\Delta X} = Py_1 \frac{\Delta Y_1}{\Delta X} \ ;$$

$$Py_2 \, . \, MPPxy_2 = Py_1 \, . \, MPPxy_1;$$

$$VMPxy_2 = VMPxy_1$$

Thus, revenue from the limited amount of input, X, will be a maximum when the value of the marginal product of the input is the same in each enterprise. (The notation, $MPPxy_1$ and $VMPxy_2$, is used to denote the MPP of X on Y_1 and VMP of X used on Y_2 respectively). Equating the VMP's of the input in the two enterprises leads to the identical solution obtained from the production possibility curve. The two criteria are compared in Table 12.1 (a) and 12.1 (b) below:

Table 12.1(a) Comparing the Marginal Criteria for Resource Allocation and Production Possibility Curve

Variable Input (X)	Output (Y_1)	MPP_{XY1}	VMP_{XY1} @Py_1= Re.1/unit	Variable Input (X)	Output (Y_2)	MPP_{XY2}	VMP_{XY2} @Py_2= Rs.2/unit
0	0	-	-	0	0	-	-
1	12	12	12	1	7	7	14
2	22	10	10	2	13	6	12
3	30	8	8	3	18	5	10
4	36	6	6	4	22	4	8
5	40	4	4	5	25	3	6

For two units of input, one to Y_1 where it would earn Rs.12 and the second to Y_2 for an earning of Rs.14, the total revenue would be Rs.26. The second unit could also go to Y_2 and the earning would be unchanged. From the production possibility curve for 2 units of input, in Fig.12.7, maximum revenue combination

Table 12.1(b) Comparing the Marginal Criteria for Resource Allocation and Production Possibility Curve

Units of Inputs Available	Solution Equating VMP			Solution using Production Possibility Curve		
	Y_2	Y_1	TR	Y_2	Y_1	TR
2	7	12	26	9	9	27.0
4	13	22	48	15.5	17.5	48.5
7	22	30	74	21.5	31.5	74.5
9	25	36	86	25.5	35.0	86.0

Py_1 = Re.1; Py_2 = Rs.2.

of outputs is 9 each of Y_1 and Y_2 and the total revenue is Rs.27 which is slightly more than the allocation using "average" marginal criteria. The numbers 2, 4, 7 and 9 given the fig.12.7 are input levels of production possibility curves. The numbers 27, 48.5, 74.5 and 86 are revenue levels of iso revenue lines. Thus, the geometric approach is more accurate. This allocation of inputs between products can also be viewed in terms of opportunity cost. It demonstrates the cost in terms of the value of an alternative product that is given up rather than the purchase price of variable input. As long as VMP in one enterprise, that is sacrificed, equals the VMP in the other enterprise, that is gained, the opportunity costs for both enterprises are equal and total returns are maximum.

B. EQUI - MARGINAL PRINCIPLE

In input-output relationship, MC=MR is the economic principle used to determine the most profitable level of variable input. But it is under the assumption of unlimited availability of variable input. Such an assumption of unlimited resources is unrealistic. So, in real world situations, the equi-marginal principle is useful in determining how to allocate limited resources among two or more alternatives. The principle says: If a scarce resource is to be distributed among two or more uses, the highest total return is obtained when the marginal return per unit of resource is equal in all alternative uses.

i) One Input - Several Products: Suppose, there is a limited amount of a variable input to be allocated among several enterprises. For this, the production function and product prices must be known for each enterprise. Next, the VMP schedule must be computed for each enterprise. Finally, using the opportunity cost principle, units of input are allocated to each enterprise in such a way that the profit earned by the input is a maximum. Profit from a limited amount of variable resource is maximized when the resource is allocated among the enterprises in such a way that the marginal earnings of the input are equal in all enterprises. It can be stated as: $VMPxy_1 = VMPxy_2 = ... = VMPxyn$ where, $VMPxy_1$ is the value of marginal product of X used on product Y_1; $VMPxy_2$ is the value of marginal product of X used on product Y_2; and so on.

Table 12.2 Allocation of Limited Variable Input among Three Enterprises

Enterprise I (Maize) Y_1			Enterprise II (Sorghum) Y_2			Enterprise III (Ragi) Y_3		
X	Y_1	VMP_{XY1}	X	Y_2	VMP_{XY2}	X	Y_3	VMP_{XY3}
0	0	-	0	0	-	0	0	-
1	10	20	1	18	18	1	7	14
2	18	16	2	31	13	2	13	12
3	24	12	3	42	11	3	18	10
4	29	10	4	51	9	4	22	8
5	33	8	5	58	7	5	25	6
6	36	6	6	64	6	6	27	4

(Py_1 = Rs2; Py_2 = Rs 1; Py_3 = Rs 2)

Suppose that the farmer has five units of X. According to the opportunity cost principle, he will allocate each successive unit of input to the use where its marginal return, VMP, is the largest; i.e., first unit of X used in I earns Rs.20; second on first unit of II earns Rs18; third on second unit of I earns Rs.16; fourth on first unit of III earns Rs.14; and fifth on second unit of II earns Rs.13. Two units of inputs go on I, two on II and one on III. Used in this manner, the five units of inputs will earn Rs.81. No other allocation of the five units among the three enterprises will earn as much. What is the maximum amount of input needed for enterprises I, II and III? To find out this, the manager must determine the most profitable amount of input for each enterprise. When input cost is Rs.6.5 per unit, the optimum amounts are 5 for I, 5 for II and 4 for III. Cost is Rs.91 (5+5+4=14) (6.5)=Rs 91. Thus, the manager would never use more than a total of 14 units of inputs on I, II and III, no matter how many units of inputs he could afford to buy.

ii) Algebraic Example

Corn response to nitrogen production function is: $C=65.54+1.084NC - 0.003N_C^2$ . . .(1)

Sorghum response to nitrogen function is: $S = 68.07+0.830N_S - 0.002\ N_S^2$ . . . . . . (2)

Assume that the farmer has 100 kgs of nitrogen available for 2 acres- one acre to be used for corn and one to be used for sorghum and that the price of corn is Rs.3 per kg and the price of grain sorghum is Rs2.50 per kg.

The allocative equations would be $VMP_{NC} = VMP_{NS}$ (or) P_c MPPnc $= P_s$ MPPns

$VMP\ N_c = (1.084 - 0.006\ Nc)\ (3) = Rs.\ (3.252 - 0.018\ Nc)$

$VMP\ Ns = (0.830 - 0.004\ Ns)\ (2.50) = Rs.\ (2.075 - 0.01\ Ns)$

Substituting Ns = 100 – Nc, we get, 3.252 – 0.018Nc = 2.075 – 0.01 (100 – Nc), and Ns = 100 – 77.8 = 22.2.

$C = 65.54 + 1.084\ Nc + 0.003\ Nc^2 = 131.71668 \times 3 = Rs.395.15$

$S = 68.07 + 0.83\ Ns - 0.002\ Ns_2 = 85.51o32 \times 2.5 = Rs.\ 213.78$

Thus, the corn would get 77.8 kgs of nitrogen and sorghum would get 22.2 kgs. This allocation equates the value of marginal products and assures the largest return from 100 kgs of nitrogen. Substituting 77.8 Kgs of nitrogen into VMPNc equation and 22.2 Kgs into VMPNs equation, demonstrates that the VMP's are equal to Rs.1.85.

iii) Two inputs - Two outputs: Consider the case in which two inputs X_1 and X_2 can be used to produce two products, Y_1 and Y_2. When the inputs are used in the first enterprise, the equi-marginal principle dictates the following equality:

Thus, the marginal earnings of each input must be the same per unit cost, even within a specific enterprise. When both ratios equal one, the optimum has been reached. The same condition must hold for the use of the two inputs in the second enterprise.

Marginal returns per rupee spent on input must be same for both inputs in enterprises. Thus, the general condition is:

Lecture No.12

Concepts of Risk and uncertainty - types of uncertainty in agriculture - managerial decisions to reduce risks in production process

i) Perfect Knowledge: Under this situation, technology, prices and institutional behaviour would be known with certainty for any period of time in future. However, this situation does not reflect the real world situation.

ii) Imperfect Knowledge: An imperfect knowledge situation can be classified either as risk or uncertainty. Risk represents less imperfection in knowledge than does uncertainty. Under risk, the occurrence of future events can be predicted fairly accurately by specifying the level of probability. When a risk situation prevails, at the time of harvesting paddy, the chances for a cyclone are 5: 95 or 20: 80. *A priori* risk prevails, when sufficient advance information is available about the occurrence of an event. E.g. the probability of a head or a tail turning up is 50: 50, if an unbiased coin is tossed. Contrary to this, statistical risk can only be predicted on the basis of occurrence of several observations made in the past. Mortality tables of insurance companies provide good examples of statistical risk. An insured vehicle meeting with an accident or an insured house catching fire or being burgled can be assigned probabilities based on the past experience of any country. Because of the quantification of imperfect knowledge-under risk situation, the event can be insured. If the occurrence of an event cannot be quantified with the help of probability, then that situation is

called uncertainty. Thus, future occurrence of an event cannot be predicted. Therefore, it becomes essential to formulate some estimates, however wild, of the most likely outcomes. E.g. price uncertainty.

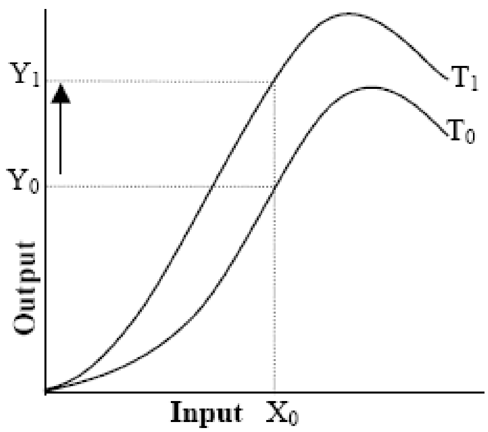
iii) Types of Risks and Uncertainties: Risks and uncertainties can be classified into the following five categories.

a) Economic Uncertainties: In general, farmers in most countries face differences in price for the inputs and outputs from what they might have anticipated at the time of preparing farm plan.

b) Biological Uncertainties: Rain or storm, drought and also by increased incidence of pest and diseases may all affect the yield in agriculture directly or indirectly

c) Technological Uncertainties:

Technological improvement necessarily implies that the same level of input can now produce larger quantity of produce. The upward shift in the production function signifies that more output can be produced at each level of input after technological progress. This effect would-be due to the delayed operation of the law of diminishing marginal returns. Thus, improvement of knowledge or technological progress, which is a



a continuous phenomenon, may render some techniques less efficient and finally

obsolete. In the fig.15.1, for the same input level X_0, the yield is increased from Y_0 to Y_1 due to technological improvement from T_0 to T_1.

d) Institutional Uncertainties: Institutions like government, bank, etc may also cause uncertainties for an individual farmer. Crop cess, credit squeeze, price supports, subsidies, etc. may be enforced or withdrawn without taking an individual farmer into confidence. This type of uncertainty may also result in non-availability of resources in appropriate quantity and at the appropriate time and place.

e) Personal Uncertainties: The farm plan may not be executed or delayed

n or co-efficient of v

$\Sigma\,(Xi - X)^2$.

i =1

Variance =

.n n

2

Σ (Xi – X)

. i =1

n .

SD

Co-efficient of Variation = × 100 %

MEAN

Standard Deviation =

because of some mishap in the farmer's household or in his permanent labour force.

iv) Safeguards Against Risks and Uncertainty

Some farmers take more risk than others. However, all farmers use one or more measures of different types to safeguard themselves against risks and uncertainties on their farms. The various measures generally used to counter risks and uncertainties in agriculture are as follows: 222

1) Selection of enterprises with low variability: There are certain enterprises where the yield and price variability are much lower than for others. For example, rice has relatively much less variability in its yields and prices than tomato. Thus, the inclusion of enterprises with low variability in the farm plans provides a good way to safeguard against risks and uncertainties. In practice, the data on yields and prices of different enterprises over a period of time may be used to measure the extent of variability by using statistical concepts like. variance or Co effiecient of Variation.

$$\text{Variance} = \frac{\sum_{i=1}^{n} (Xi - \bar{X})^2}{n}$$

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n} (Xi - \bar{X})^2}{n}}$$

$$\text{Co-efficient of Variation} = \frac{SD}{MEAN} \times 100\ \%$$

Table 15.1 Estimates of Farm Income

Year	Farm Income (Rs / Year)	$(Xi - X)^2$
1996	2500	688900
1997	3000	108900
1998	3200	16900
1999	3800	220900
2000	4150	672400
Total	16650	1708000

Mean = 3330; Standard Deviation = √1708000/5 = 584.4656
CV = 584.4656 / 3330 = 17.55 per cent.

2) Discounting Returns: At this stage, we refer to discounting only as a function of risk and uncertainty, and not time. In terms of the profit maximization condition of VMP = Px, discounting means that either the output price (Py) is decreased or input price (Px) is increased by some proportion or it can be of both. Thus, the profit maximization level of the variable input X_1 may now be lower with discounting than otherwise.

3) Insurance: Insurance covers the cost to some extent so as to minimize the loss.

4) Forward Contracts: They reduce the future prices of both inputs and outputs into certainty. Pre-harvest contracts of mango, share cropping, i.e., forward contract in kind are some examples for this.

5) Flexibility: This refers to the convenience with which the organization of production on a farm can be changed.

a) Time Flexibility: Time flexibility may be introduced either through proper selection of products or production methods or partly by both. Orchard plantation is a relatively rigid enterprise than annual crops. A short-lived farm structure is more flexible that the durable.

b) Cost flexibility: Wherever time flexibility is of limited use, cost flexibility becomes important. Cost flexibility refers to variations in output within the structure of a plant of a longer life. Extension or concentration of output, whenever desired by favourable prices or yields can be brought about at lower cost for a given farm (plant). Owning rather than custom hiring a power tiller may have more cost flexibility.

c) Product flexibility: Product flexibility aims at changes in production in response to price changes. In this category, machines, farm structure, etc, can be readily shifted from one product to another.

6) Liquidity: This refers to the case with which assets in a farm can be converted into cash, the most "liquid" of all assets. If some of the assets are held in the form, which can be easily converted, into cash, it provides a safeguard to the farmer by enabling him to make necessary adjustments in response to risks and uncertainties of various types.

7) Diversification: It is a means of stabilizing incomes rather than profit maximizing technique relating to receive benefits of complementarity or supplementarity. Under risky environment, a farmer may not specialize in a single enterprise over a period of time even if substitution and price ratios may so dictate as discussed under product-product relationship. Instead, he may

choose several enterprises in some proportion overtime, so as to distribute the risk factor. Like flexibility, it has no provision to reap large gains due to high prices or yields over time, but serves as a good method to prevent heavy losses. However, the diversification of farm activities may deprive the entrepreneur of all the advantages of specialization.

8) Maintenance of resources in reserve: Many a time, there is a risk or uncertainty about the availability of the right inputs, in the required quantity at the right time and place and at a reasonable price. This may be due to the imbalance between demand and supply of the resources. To overcome this problem, the best way is to maintain sufficient stocks of such inputs. Maintenance of sufficient stocks depends on the availability of funds, his ability to fore cast prices and the availability of resources and storage facilities in the farm.

9) Adjustment to uncertain of Inputs: When a resource is not available, the best way the farmer can safeguard against such risk and uncertainty is by exploring the use of some other resource as a substitute. If a farmer is uncertain about the availability of inputs, he would do better by choosing the best alternatives, i.e., sowing the second best variety, using the second best fertilizer, using the second best method of harvesting etc.

Lecture No.13

Management of Important Farm Resources

The farm problems can be classified according to the major factors of production - land, labour, machinery, equipments and buildings.

i) Land Management

Land is a permanent resource, which does not depreciate or wear out provided soil fertility is maintained and appropriate conservation measures are used. It includes soil management, farm layout, and crop rotation and management.

a) Soil fertility can be replenished by:

1) Proper cultivation and fallowing.

2) Addition of manures and fertilizers.

3) Growing leguminous crops.

4) Eradication of weeds.

5) Leveling and bunding.

6) Drainage in water - logged soils.

7) Land reclamation in saline and alkali soils.

b) Efficient Lay-out

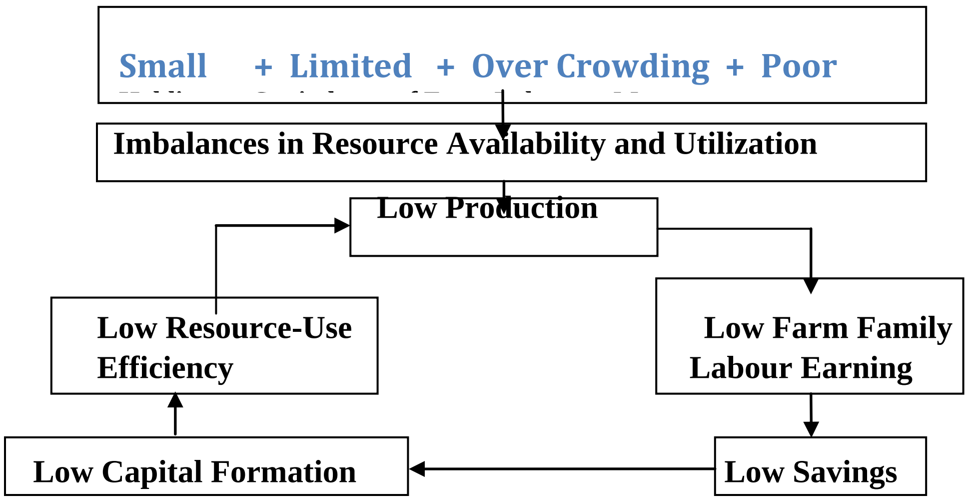
Layout of a farm refers to the manner in which a farm is divided into fields and the location and arrangement of other fixtures such as irrigation and drainage system, buildings and sheds, roads and fencing. Layout of a farm directly affects the costs and efficiency in the use of farm resources. An efficient layout is the one which takes into consideration the topography of the land, fits in well with the enterprises and crop rotations, leads to the saving of labour and ensures efficient checks and controls on farming operations.

c) Crop rotation plays a major role in depletion and improvement of soil fertility. Inclusion of leguminous crop improves soil fertility. Cropping system refers to the sequences of crops grown to maintain the fertility of soil.

ii) Farm Labour Management

Labour efficiency in agriculture refers to the amount of productive work accomplished per man on the farm per unit of time. Inefficient labour also results in low production, which in turn means low wages for the labour.

On Indian farms, land is limited and labour is abundant. The resource availability on the farms is, thus, imbalanced leading to a low production and in turn results in low farm family labour earnings.



a) Classification of Farm Labour: In India, farm labour can be classified into:

1. Farm manager labour: Indian farmer is a manager, capitalist and a labourer.
2. Family labour
3. Permanent hired labour.
4. Casual labour.

b) Improving the Efficiency of Farm Labour: In order to increase the overall production and also to improve the resource use efficiencies of other resources, the efficiency of farm labour has to be improved. Labour efficiency can be improved by:

1) Enlarging the size of farm business - expansion of land area, adding more labour intensive enterprises.

2) Planning labour distribution -enterprise combination (mixed farming).

3) Improving farm lay-out (defective lay-out results in wastage of labour in operations like ploughing, planting, etc.

4) Improving labour management with incentive and training of the workers.

5) Simplification of farm work (Its objective is a more efficient use of labour and other resources by improving work methods so that more and higher quality of work is accomplished in less time with less energy).

iii) Management of Farm Machinery

Due to seasonal nature of agricultural operations, the farmers are facing difficulty in timely and successful performance of agricultural operations, especially during the peak labour use periods; at the time of sowing, harvesting and threshing. In order to smoothen these peaks, labour saving devices can be introduced by mechanizing some selected agricultural operations. Then, the farmer has to decide how much capital he should invest in machinery and which machines he should buy, whether to hire rather than buy a machine.

a) What cost to take into account?

Only additional costs involved should be considered when making decisions on machinery investment. For example, for implements drawn by bullocks, feed costs can be ignored because bullocks have to be fed any way. Only where the bullocks are fed more, because the new implement demands that, feed costs can be added. Partial budgeting technique is used to calculate the economics of buying a machine in this case.

b) Rate at which costs are to be charged?

Since the farmer purchases future services when he buys a machine, he should consider expected future costs of fuel, oil, taxes, interest, etc rather than past or present costs. If a farmer borrows money to buy a machine the actual interest rate paid is the appropriate charge to make. The opportunity cost of capital should be considered to assess the interest charges on the machine, if the farmer has severe financial constraints.

c) Selection of size of machine to buy: The key points to be considered while deciding upon the size of a machine are as follows: 1) The difference in the initial cost of the large and small machines, 2) The annual use to be made of the machine and 3) The amount of additional labour saved by the large machine.

d) Break Even Analysis: Break-even point is the minimum size of operation required to meet the total costs. At this point, the total cost and total revenue break even, i.e., the profit is equal to zero. For deriving the break even point:

$$Q = \frac{F}{P - V}$$

Where Q = quantity of output.

F = Annual fixed cost.

P = Custom charges per unit of output.

V = Variable cost per unit of output.

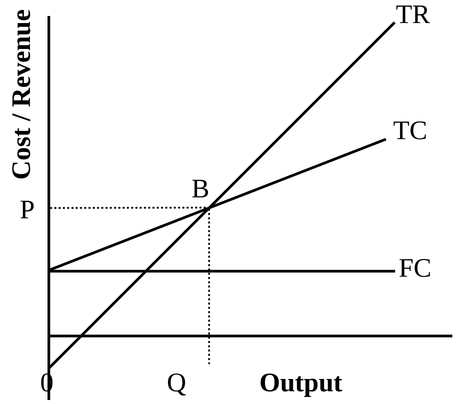


Fig.18.2 Break-Even Output

If F=Rs.3,500, P=Rs.8 for threshing one quintal of paddy and V=Rs.3, then the break even point for a paddy thresher is given by : Q= 3,500/[8.00-3.00]= 700 quintals. In order to cover the total costs, the thresher has to thresh 700 quintals of paddy per year. Unlike in the break-even analysis for direct production investments, in this case, P is taken as custom charges (instead of price); because if the farmer does not buy this machinery, he should have to hire the machinery for which some rate is charged. So the custom charge is taken as the price of the particular operation per unit time. Break-even point is graphically represented in the figure 18.2. Here, OQ is the break-even output level.

iv) Management of Farm Buildings

The main purpose of farm buildings is to store farm equipments, to maintain and preserve stored products, provide shelter to the livestock and ensure efficiency of operations. Building has to be constructed only, if there is an urgent need for it. Buildings have to necessarily increase the efficiency of other farm operations and thereby the farm income. Economy in construction and management and sanitary and comfortable conditions are essential requirements of a building. Some important steps to be followed in attaining these objectives are: a) determination of the functional requirements of the structure; b) designing of the structure for flexibility to meet changing demands; and c) designing for the least economical method of construction which should meet the standards for particular structure. For every farm situation, one has to decide:

1) What should be the type of building?
2) Whether to construct a new building or to remodel the old one?
3) What should be the optimum size and design of the building?
4) To what extent the farm building should be flexible in design?

After deciding the above points, careful decisions have to be made on location, orientation with respect to sun and wind, sequence of operations, hygienic conditions etc.

a) Buildings as an Input

Buildings like machinery, livestock, labour and land are a resource essential to the farm production. As it is used along with the other resources, marginal investments made on farm buildings must bring the highest returns to the farmer. Farm buildings increase income of the farm through saving labour, increasing the quantity of production and improving the quality and time value of crop and livestock products. Buildings, therefore, must be provided, where the operations can be carried on efficiently.

Lecture No.14. Farm Financial Analysis - Balance sheet - Income statement - Cash flow analysis - Ratio analysis

A. FARM BUSINESS AND CONTROL

Efficient managers want to be able to determine the position of a business at any point of time. They also want a basis for evaluating where the business is going on. This helps their control of the business operations overtime. Thus, the objectives of farm business at a particular point of time are:

i) to evaluate the performance of the business at a particular point of time;

ii) to identify the weakness of the business;

iii) to remove the hurdles and improve the business; and

iv) to prepare financial documents like balance sheet and income statement so as to acquire credit, design farm policies and prepare tax statement.

i) Steps or Stages of Farm Business Analysis

a) Proper recording of accounts and activities.

b) Analysis of the data.

c) Interpretation of the results.

a. Recording of data: A systematic recording of information on financial aspects of the farm is essential for farm business analysis and for this purpose, a sound knowledge on book keeping and accounting is essential.

b. Analysis of data: The data collected would be useful to construct balance sheet and income statement. Financial ratio analysis would also increase the farm efficiency.

c. Interpretation of the results: The financial analysis would indicate the performance of the business and suggest measures for improvement. The interpretation of results would be more useful to understand the performance of the business.

ii) Advantages of Farm Records and Accounts

a) They are the means to increase the farm income.

b) They are the basis for diagnosis and planning.

c) They show the ways to improve the managerial ability of the farmer.

d) They are useful for credit acquisition and management.

e) They provide database for conducting research in agricultural economics.

f) They form the basis for designing government policies - land policy, price policy, national farm policies, etc.

iii) Problems in Farm Accounting

a) As Indian farmers carry out only subsistence nature of farming, recording is not essential to them.

b) Indian farmer acts as an owner, manager and labourer. Hence, recording becomes complex.

c) Illiteracy and lack of business awareness of farmers prohibit them to have farm records.

d) Fear of taxation prevents farmers from recording and accounting the information.

e) Forecasting becomes complicated because of very high risk and uncertainties involved in farming.

iv) Types of Farm Records: Farm records can be classified into three categories, i.e., inventories, production records and financial records.

a) Inventory: Farm inventory includes a complete listing of all that a farm owns and owes at a particular date, generally at the beginning and the end of each agricultural year. It includes not only the listing of physical assets but also assigning values of all such assets, liabilities and debts as well. There are two steps involved in taking a farm inventory.

1) Examination of Physical Assets: It includes a complete listing of all the physical assets including a verification of weights and measurements. The losses, wastages, shrinkages or gains, which accrue over time, are all accounted for.

2) Valuation of Physical Assets: A few common methods of valuation are discussed below:

i) Valuation at Cost: The amount of money actually invested on the asset when

Return per Year (R) 1,000
Present Value (PV) = = = Rs. 10,000
Interest Rate per Annum (r) 0.10
it was acquired is entered in the inventory. This method has the following limitations: a) it cannot be used for the valuation of farm products; b) the effects of inflation and deflation are ignored; and c) original investment value has only a limited use, when valuation is taken up somewhere in the middle of the business.

ii) Cost or market prices whichever is lower: This is used for valuing the purchased farm supplies.

iii) Net Selling Price: It represents market price less the selling costs. For all assets that will be sold within the year, the net selling price is used. Crops or livestock produced for the market can be valued with this method.

iv) Cost Less Depreciation: The value of asset in subsequent years can be estimated by subtracting the depreciation from its cost. Machinery, breeding livestock and buildings constructed recently can be evaluated with this method. But this method cannot be applied for products produced from the farm.

v) Replacement Cost: It represents a value of an asset, which is equal to the cost needed to reproduce the asset at the present prices and under the existing technological improvements. This method may be successfully employed for the valuation of fixed and long-lived assets.

vi) Replacement Cost less Depreciation: It represents an improvement over the previous method as it provides a more realistic valuation of fixed and long-lived assets like buildings, particularly, when wide price changes occur. However, this method should be used very carefully as it may often lead to over valuation.

vii) Income Capitalization: For assets like land whose contribution towards the income can be measured for each production period and which has long life, income capitalization is an ideal method of valuation. If a certain piece of land is expected to give an uniform income of Rs.1,000 per year indefinitely and the rate of interest is 10 per cent per annum, the present value of the land, then, can be easily assessed by using this method, i.e., 227

Thus, the piece of land in question would be valued at Rs.10,000.

Farm planning and control ? Elements of planning, objectives, steps and formulation of farm plans - Farm level management information systems- Farm Budgeting ? partial, enterprise and complete budgeting.

Production Records

These records provide information on the input-output relationship of different enterprises on the farm. These information are useful both for measuring production efficiency and preparing efficient farm plans. Production records have limited utility, as they do not indicate the financial position.

However, they show the quantity and time of application of various resources to different enterprises on the farm and the yield and other physical performance of different enterprises. Some of the popular physical records are: a) Farm Map, b) Crop Records (season, crop and yield particulars), c) Livestock Feed Record, d) Production Record of Livestock and e) Labour Records (to study labour efficiency and seasonal requirement of labour).

c) Farm Financial Records

Farm financial records provide valuable information on economic efficiency of the farm.

1) Cash analysis account book is the most important financial record to be maintained by the farmer. The cash transactions, expenses and receipts, are recorded in a cash analysis book as shown in table 16.3.

2) Trading Account: Trading Account is often used interchangeably with “profit and loss account”. All the items in the cash analysis account book are repeated in this trading account. Purchases and expenses are put on the left-hand side and the sales and receipts on the right-hand side. Also, the closing valuation is put on the right-hand side and the opening valuation on the left-hand side. If the right-hand side total is greater than that of the left-hand, the farm has earned profit. The profit is entered on the left-hand side but the loss on the right-hand side. The trading account is prepared at the end of the year.

Table 16.4 Trading Account for the Year ending 31.06.2001

Purchases and Expenses	Amount (Rs)	Sales and Receipts	Amount (Rs)
Opening Balance as on 1-7-2000	1,10,000	i) Paddy	4,400

i) Wages	3,400	ii) Sorghum	600
ii) Feeds	1,400	iii) Ground-nut	1,500
iii) Seeds	460	iv) Milk	4,560
iv) Fertilizers	1,340	v) Others	700
v) Rent	1,800	Closing Valuation as on 30-6-2001	1,15,000
vi) Fuel	900	Total	1,26,760
vii) Others	700		
Total	1,20,000		
Net Profit	6,760		
	1,26,760		1,26,760

Table 16.3 Cash Analysis Account Book

(Amount in Rs)

Sales and Receipts								Purchases and Expenditur				
Date	Name and Details	Total Received	Cereals	Oilseeds	Milk	Others	Date	Name and Details	Total Paid	Wages	Feeds	Fertilizers
1-4-2000	Opening Balance	11000	-	-	-	-	-	Wages	3400	3400	-	-
	Paddy	4400	4400	-	-	-	-	Feeds	1400	-	1400	-
	Sorghum	600	600	-	-	-	-	Fertilizers	1340	-	-	1340
	Ground-nut	1500	-	1500	-	-	-	Seeds	460	-	-	-
	Milk	4560	-	-	4560	-	-	Rent	1800	-	-	-
	Others	700	-	-	-	700	-	Fuel	900	-	-	-
								Others	700	-	-	-
	Total	22760	5000	1500	4560	700		Total	10000	3400	1400	1340

Closing balance in the bank (as on 31-3-2001) =Rs.22760 – 10000 = Rs. 12,760.

Opening balance as on 1-4-2001=Rs.12760.

3) Income Statement

Income statement indicates how well the farm business has performed during the accounting period. From this, we can get an idea of the returns to various resources after deducting the expenses and also about overall earnings of the farm. This is an important financial record because it measures the financial progress and profitability over a period of time. It is a summary of both cash and non-cash transaction of the farm business. In non-cash financial transaction, we get capital gain and depreciation. Income statement is divided into two major categories, viz., income and expenses. Income includes cash receipts, capital sales of business and changes in inventory value of items produced in the farm. Expenses include operating and fixed expenses.

i) Inventory: It is a complete listing of all assets. Items like supplies, grain and feed held for sale are listed on the inventory form.

ii) Capital Sales of the Business: The sale of milch animals and equipment are major items under this heading. These types of receipts are separated from normal cash receipts because they must be reported differently on tax forms.

iii) Changes in Inventory: In making adjustment for changes in inventory value, both changes in price and quantity should be taken into consideration. If the ending inventory value is greater than the beginning inventory value, it should be treated as a form of income. If opposite holds true it should be considered as negative income.

iv) Operating and Fixed Expenses: Operating expenses generally vary with the size of the business operation. But fixed expenses do not significantly vary with changes in volume of business done under the period of reporting.

4) Net Worth Statement

Net worth statement is also known as balance sheet. It is a summary of assets, liabilities and owner's equity (net worth) at a given point of time. This statement shows the value of assets that would remain, if the farm business is liquidated and all the outside claims against the business are paid. A business is considered solvent, if the value of assets exceeds debt level. It is very useful for the lender for scrutinizing the loan application. Net worth = Assets - Liabilities.

i) An asset can be defined as "anything of value in the possession of the farm business or a claim for anything of value in the possession of others". Farm inventory, farm cash and accounts constitute the assets. Farm assets can broadly be classified into the following three main categories.

Table 16.5 Income Statement (1st July 2000 to 30th June 2001)

(Amount in Rs)

Receipts	**Amount**	**Expenses**	**Amount**
I Cash Receipts		**I Operating Expenses**	
1. Paddy sales	7,500	1.Hired labour	3,000
2. Sugar cane sales	5,500	2. Hired bullock labour	4,000
3. Ground-nut sales	12,000	3.Fuel and repairs for machineries	2,500
4. Milk sales	6,500	4. Fertilizers	1,500
5. Broiler sales	12,000	5. Other crop expenses (seed and spray of chemicals)	2,400

6.Miscellaneous income (hired out human and bullock labour)	1,500	6.Livestock and veterinary expenses.	1,000
Sub-Total	45,000	7. Interest on current debt	600
II Net Capital Gain Income		8. Other miscellaneous expenses	700
1. Sale of purchased milch animal	2,000	Sub-Total	15,700
2. Sale of farm bred animal	2,000	**II Fixed Expenses**	
3. Sale of machinery	2,000	1. Land rent	3,000
Sub-Total	6,000	2.Land revenue, cess and surcharge, water charge, etc	800
III Change in Inventory Value		3. Land development	4,200
1.Crop inventory	4,000	4. Interest on intermediate and long term loan	1,000
2. Livestock inventory	1,000	5. Equipment depreciation	1,500
Sub-Total	5,000	6. Livestock inventory change	1,000
Gross Farm Income	56,000	7. Imputed value of family labour	1,000
Net Farm Income	**25,700**	8. Building inventory change	600
		9. Imputed value of operator's management	1,500
		Sub-total	14,600
		Total Expenses	**30,300**

Table 16.6 Net Worth Statement (as on 30th June, 2001)

(Amount in Rs.)

Assets	Amount	Liabilities	Amount
I Current Assets		**I current Liabilities**	
1. Cash in hand	500	1. Cash expenses in seeds, feeds, fertilizers, repairs, etc	12,000
2. Cash in bank	2,500	2. Interest on intermediate and long term liabilities	4,500
3. Prepaid expenses for Goods not yet Received)	2,500	3. Taxes	500
4. Grains, seeds, feeds and supplies	25,000	4. Rent	2,500
5. Cash investment in growing (standing) crops	5,000	5. That portion of intermediate and long term debt	6,000

Total-Current Assets	35,500	Total- Current Liabilities	25,500
II Intermediate Assets		**II Intermediate Liabilities**	
1.Machineries and equipment	20,000	1. Sale contracts	2,000
2. Livestock	25,000	2. Intermediate or medium term loan (balance due beyond 12 months)	16,000
3. Securities not readily marketable	5,000	Total- Intermediate Liabilities	18,000
Total – Intermediate Assets	50,000	**III Long Term Liabilities**	
III Fixed Assets		1. Mortgage on land	12,000
1. Land (4 ha)	4,00,000	2. Land contract	5,000
2. Buildings	1,50,000	Total – Long Term Liabilities	17,000
Total – Fixed Assets	5,50,000	**Total Liabilities**	**60,500**
Total Assets (I+II+III+)	**6,35,500**	**Net Worth =Total Assets – Total Liabilities**	**6,35,500– 60,500 = Rs.57500**

a) Current Assets: Cash on hand or in the bank and other assets in the possession of the farm, which may be liquidated in the normal operation of the business like products held for sales and supplies are called current assets. The liquidation of these items will have the least effect on the business to continue its operation.

b) Working Assets or Intermediate Assets: Assets which are normally used up during the life of the business such as farm equipment and machinery, breeding and producing livestock can be categorized under this. They have the life of one to ten years. The liquidation of these assets would have a significant influence on business activity. These assets are somewhat more difficult to liquidate than current assets.

c) Fixed Assets or Long Term Assets: Assets like land, building and land improvements are difficult to convert into cash. They are long-term permanent assets. These are not likely to be liquidated. If a major portion of these assets were liquidated, the business would also be terminated in most cases. The sum of current, intermediate and long-term assets is the total assets of the business. The claim against is divided between debts of the business and owner's equity (net worth).

ii) Liability: A liability is defined as, "a claim by others against the farm business, like mortgages and accounts payable". Liabilities can be classified into:

a) Current Liabilities: Liabilities, which call for immediate payment, generally within one year and which cannot be deferred, are called the current liabilities. They include rents, taxes and interest, plus that portion of principal on intermediate and long-term debt due within the next twelve months.

b) Intermediate Liabilities: They are also known as medium term liabilities, which can be deferred for the present. They are not of immediate concern but have to be paid between one and ten year period.

c) Long-term Liabilities: Any deferred liability, which has to be met after ten years and generally upto 20 years, is called the long-term liability. They consist of mortgages and land contracts.

iii) Net Worth

Net worth is estimated by subtracting total liabilities from total assets. It reflects the owner's equity in the business and in other personal property. The net worth statement is one of the primary documents used by lending agencies in evaluating requests for new loans or extension of existing loans. It is also useful for calculating financial ratios of the farm business.

B. SYSTEMS OF BOOK KEEPING

There are two systems of farm accountancy, namely, i) Singly entry system and ii) Double entry system.

i) Single Entry System: This system ignores the double effects of transactions, namely, receipts and payments. It is therefore, relatively imperfect. Its results are less reliable and its accuracy cannot be tested by means of a trail balance, which is possible under the double entry system alone.

ii) Double Entry System: Every transaction is recorded twice in the accounts, i.e., to the debit side of one account and to the credit side of another. Each category of assets, liability, expense and income will be allocated an account in the ledger and this account will usually be divided into a debit (entry of a sum owing) (left hand side) and credit (right hand side). Each transaction has a two fold aspects of giving and receiving. The giving account is credited. The receiving account is debited, i.e., receiving cash is debited. Giving goods (sales account) is credited. In selling paddy for Rs 1200, there are two accounts, viz., cash account and paddy account. The cash account will be the receiving account and hence the amount will be written on the debit side of it. The paddy account will be the giving account; hence the amount will be written on the credit side of it. One of the in-built checks of a double entry system in that a trial balance can be prepared and the failure of the trial balance to balance credit and debit indicates that there are errors in the accounts. Since every debit entry in a ledger has a corresponding credit entry or entries, it follows that the total debit and credit balances in the accounts must be also equal. The double entry system has a number of advantages over other systems. They are as follows:

a) It can record all types of transaction.

b) Full information can be extracted quickly from the accounts at any time.

c) A check on arithmetical accuracy is built into the system.

A good farm record system should: i) be easy to keep; and ii) provide needed information for analysis.

iii) Financial Ratio Analysis: The financial ratio analyses would useful to assess the performance of the farm business.

1. **Net capital ratio** = $\dfrac{\text{Total Assets}}{\text{Total Liabilities}} = \dfrac{6{,}35{,}500}{60{,}500} = 10.50.$

This is a measure of degree of financial safety over a period of time by comparing the present position of the business with that on some previous date. Higher the ratio, safer will be the position of the farmer.

2. Current ratio = $\dfrac{\text{Current Assets}}{\text{Current Liabilities}} = \dfrac{35{,}500}{25{,}500} = 1.39.$

It measures the ability of the farm to meet its current liabilities. Higher the current ratio, the greater the short term solvency.

3.Acid test ratio = $\dfrac{\text{Quick Assets}}{\text{Current Liabilities}} = \dfrac{28{,}000}{25{,}500} = 1.10$

Quick assets are defined as current assets excluding inventories. Acid test ratio is also known as quick ratio, which is a stringent measure of liquidity. It is based on those current assets, which are highly liquid, i.e., inventories are excluded from current assets, as they are the least liquid component of current assets.

4. Debt-Equity Ratio = $\dfrac{\text{Debt (Total Liabilities)}}{\text{Owner's Equity or Net Worth}} = \dfrac{60{,}500}{5{,}75{,}000} = 0.11$

Lower the debt, the higher degree of protection enjoyed by the creditors. The lower this ratio, the more desirable it is. It is also known as Debt to Net Worth ratio. The net worth indicates the solvency of the business. But this is the ultimate solvency rather than intermediate solvency. Ultimate solvency is meant that total resources are equal to or greater than total liability, in case the entire business is closed out and all the liabilities are met with. Net worth is greater than zero, when business is solvent. When total liabilities are not covered by total resources, the business is insolvent or bankrupt. The intermediate solvency is meant the relationship between current liabilities and liquid assets, which can be used to clear them off, if demanded.

5. Total Assets Turn-Over Ratio = $\frac{\text{Net Sales}}{\text{Total Assets}} = \frac{43,300}{6,35,500} = 0.07.$

This measures how efficiently assets are employed over all. It is similar to output-capital ratio used in economic analysis. The higher their ratio, the greater the turn -over of assets.

6. Net Income to Total Assets Ratio = $\frac{\text{Net Income}}{\text{Total Assets}} = \frac{25,700}{6,35,500} = 0.04$

It also measures how efficiently the capital is employed. The higher this ratio, the more sound the capital use on the farm.

7. Equity/Value ratio = $\frac{\text{Net Worth}}{\text{Total Assets}} = \frac{5,75,000}{6,35,500} = 0.90.$

Higher the ratio, better will be the financial position of the farm business.

C. FARM EFFICIENCY MEASURES

Efficiency is generally taken to mean the output input ratio without any consideration of the quality either of output or input or both.

i) Crop yield index: It is a measure by which the yields of all crops on a given farm are compared with the average yields of these crops in the locality. The yield index is a convenient measure because it represents a combined index of yields of all the crops on a farm. Average yield of the area for each crop is obtained and then the corresponding yield figures of the farm in question are

Table 16.7 Estimation of Crop yield Index

Crop	Area (ha)	Yield / Ha on the Farm (Qtls)	Total Production (Qtls)	Per Ha Average Yield in the Region (Qtls)	Area Required at the Regional Yield to Obtain the Total Farm Production (Ha)
1.Paddy	10	39	390	45	8.67
2. Maize	6	24	144	10	14.40
3.Wheat	15	32	480	28	17.14
Total	31	-	-	-	40.21

used to work out the hectares needed to have the same production as actually obtained on the farm, if area average yields prevailed. The total hectares required, at area average yields, to have the existing level of production are divided by the hectares on the farm to obtain the yield index. A figure greater than 100 indicates that the farm in question is more efficient than an average farm in the area. The crop yield index of the above farm is 40.21 / 31.00 × 100 =130 per cent. As the index is greater than 100, the selected farm is more efficiently operated in terms of crop yields as compared to an average farm in the area.

ii) System Index: This index is used for determining the rationality by which various enterprises on a certain farm are combined. It is obtained by expressing the potential net income per hectare on a farm as a percentage of the average standard net income per hectare in the area, i.e.,

$$\textbf{System Index} = \frac{\textbf{Potential Net Income per Ha on the Farm}}{\textbf{Average Standard Net Income per Ha in the Area}} \times 100$$

If the system index is more than 100, it indicates a higher level of efficiency in combining enterprises on the farm in comparison to that by an average farm in the area and vice versa. Therefore, the system index = (1000 / 900) × 100 = 111.11 per cent. However, major difficulty may be encountered in calculating this index, when the selected farm grows crops which are not usually grown in the locality.

Table 16.8 System Index

Crop	Average Standard Net Income per Hectare of Enterprise in the Area (Rs)	Area under Units of Enterprise on the Farm (Ha)	Total Potential Net Income of the Farm (Rs)
1. Paddy	1,000	10	10,000
2.Maize	500	6	3,000
3.Wheat	1,200	15	18,000
Total	2,700	31	31,000
Average	900	-	1,000

3. Intensity of Cropping: The intensity of cropping measures the extent of the use of land for cropping purposes during a given year. The gross cropped area is expressed as a percentage of net cropped area.It is expressed as a percentage.

$$\textbf{Cropping Intensity} = \frac{\textbf{Actual / Gross Area Cropped}}{\textbf{Net Cultivated Area}} \times 100$$

4. Irrigation Intensity: The gross irrigated area is expressed as percentage of net irrigated area.

$$\textbf{Irrigation intensity} = \frac{\textbf{Actual / Gross Irrigated Area}}{\textbf{Net Irrigated Area}} \times 100$$

5. Labour Efficiency: A productive man equivalency is the average amount of work accomplished by one man in the usual eight hour day (man day). Given below is a list of important measures of labour efficiency:

a) Crops acres per man or per man-year.

b) Livestock maintained per man or per man-year.

c) Gross profits per man or per man-year.

6. Machinery Efficiency: It is helpful in judging the accomplishment of the farm machinery and equipment for making changes in their investment it required. A list of some common measures of machinery efficiency is given below:

i) Machinery and equipment cost per cropped acre: Only, total annual costs are considered including repairs, fuel, depreciation, etc. in estimating the cost.

ii) Investment in machinery and equipment per crop acre.

The following are a few important cost ratios:

a) Operating ratio: It represents the proportion absorbed by operating expenses out of the gross income and is calculated as:

$$\textbf{Operating Ratio} = \frac{\textbf{Total Operating Expenses}}{\textbf{Gross Income}}$$

b) Fixed Ratio: This is calculated by dividing the total fixed costs by the gross income.

$$\textbf{Fixed Ratio} = \frac{\textbf{Total Fixed Expenses}}{\textbf{Gross Income}}$$

c) Gross Ratio: This ratio expresses the percentage of gross income absorbed by the total costs and is calculated as:

$$\textbf{Gross Ratio} = \frac{\textbf{Total Expenses}}{\textbf{Gross Income}}$$

Lecture No.15

Farm Investment Analysis - Time comparison principles - Discounted and undiscounted measures.

A. COMPARATIVE ADVANTAGE PRINCIPLE

According to this well-known principle, different areas will tend to produce those products for which they have the greatest comparative and not just absolute advantage. The main factors involved in the law are simply an extension and application of the principles of specialization and diversification. The physical and economic conditions influencing production vary from country to country, region-to-region and farm-to-farm and even within a farm from field to field. Each farm or region produces those crops or raises that livestock which it can grow more profitably. In other words, the individuals or regions tended to specialize in the production of the commodities for which their resources give them a relative or comparative advantage. For example, farmers in Tamil Nadu specialize sugarcane cultivation and those in Punjab specialize in paddy cultivation.

Table 14.1 Yield per Hectare (in Quintals) During 1996 - 1997

Crop	Punjab	Tamil Nadu
Paddy	34.0	26.7
Sugarcane	638.2	993.0

Punjab has to give up 34 qtls of paddy for 638 qtls of sugarcane whereas Tamil Nadu has to give up 27 qtls of paddy for 993 qtls of sugarcane. The principle of comparative advantage is reflected in the market prices for farm products. The following factors may change regional production pattern over time:

i) Changes in product or output prices.

ii) Changes in biological factors such as increased pest infestations.

iii) Introduction of new technology such as high yielding varieties, IPM, etc.

iv) Conversion of dry lands into irrigated lands.

v) Change in mode or cost of transportation, so as to decrease or increase the disadvantage associated with being distant from markets.

vi) Change in population that results in large, new consumption centres.

vii) Shifts in resources, such as labour and capital between regions.

B. TIME COMPARISON PRINCIPLE

In previous chapters, future prices, yields and other events relevant to the production process were assumed to be known, and problems unique to the passage of time were not considered. Since such an environment is far from reality, it is necessary to study the effect of time, risk and uncertainty on production process.

i) Decision - Making over Time

A farm manager has to take decisions over varying horizons of time. Two aspects of such decisions are important, i.e., i) differences in profitability growing out of time alone and ii) differences in the desirability of investments due to risk and uncertainty factors. Time has a very significant influence on costs and returns. There are many decisions where this time comparison principle finds application, such as: soil conservation programmes which bear fruits over a long time; putting land under an orchard which may not give returns for 5-10 years; and so on. Two aspects of the problem are considered under such situations: a) growth of a cash outlay over time and b) discounting of future income.

ii) Growth of a Cash Outlay or Compounding Present Costs

The cash outlay grows over time due to the compounding of interest charges or opportunity costs involved in using the capital; if Rs.100 are put in a saving account with an annual interest at 12 per cent compounded, it will increase to Rs.125.44 by the end of second year. In symbolic terms, you now have the amount earned at the end of the first year. P + Pi, plus the interest that amount earned during the second year (P + Pi) i which could be expressed as:

(P + Pi) + (P + Pi) i (or) P (1 + i) + Pi (1 + i) which after factorising (1 + i), results in

Table 14.2 Compounding the Present Value

(Amount in Rs.)

Year	Beginning Amount	Interest Earned by the End of Year	Beginning Amount + Interest
1	100.00	100.00(0.12)=12.00	112.00
2	112.00	112.00(0.12)=13.44	125.44
3	125.44	125.44(0.12)=15.05	140.49
4	140.49	140.49(0.12)=16.86	157.35
5	157.35	157.35(0.12)=18.88	176.23

(P + Pi) (1 + i). Factorising P from the left term gives: $P(1+i)(1+i) = P(1+i)^2$. In general, the compounded value, F (future value), of a present sum (P) invested at an annual

$$P = \frac{F}{(1 + .i)^n}$$

$$P = \frac{176.23}{(1.12)^5} = \text{Rs.}100.00.$$

interest rate (i) for ‘n’ years is given by $F = P(1 + i)^n$ .This procedure is called compounding.

iii) Discounting Future Revenues

Costs incurred at one point of time cannot be compared with validity to revenues forthcoming at a later date. The future value of the present sum is estimated through: F = P(1 + i)n .Dividing both sides of this equation by (1 + i)n, the following equation is obtained:

Thus, if a pay-off, F, is due in ‘n’ years in future, its present value, P, can be determined using the above expression where ‘i’ is the interest rate. This procedure is known as discounting future returns. The present value of Rs.176.23 that could be at the end of 5 years if the appropriate discount rate is 12 per cent, is:

Discounting can be used to determine the present value of the future income stream earned by a durable input (asset).

Table 14.3 Discounting the Future Values

(Amount in Rs.)

Year	Value at the End of the Year (Rs)	Present Value, if Discount Rate is 12 Per Cent per Annum (Rs)
1	100	89.29
2	100	79.72
3	100	71.18
4	100	63.55
5	100	56.74
Total	500	360.48

The interest rate used to discount or compound sums of money should be at least as large as the current or market rate of interest. How much higher it might be depends upon the manager’s opportunity costs. The important variables determining present and future values of a single payment or series of payments are: i) the number of years and ii) size of interest rate. Both factors interact to determine the total effects of discounting or compounding on present or future values.

Lecture No.16

Farm planning and control - Elements of planning, objectives, steps and formulation of farm plans - Farm level management information systems.

A. FARM PLANNING

Farm planning is a decision making process in the farm business, which involves organization and management of limited resources to realize the specified goals continuously. Farm planning involves selecting the most profitable course of action from among all possible alternatives.

i) Objectives of Farm Planning

The ultimate objective of farm planning is the improvement in the standard of living of the farmer and immediate goal is to maximize the net incomes of the farmer through improved resource use planning. In short, the main objective is to maximize the annual net income sustained over a long period of time. The farm planning helps the cultivator in the following ways:

a) It helps him examine carefully his existing resource situation and past experiences as a basis for deciding which of the new alternative enterprises and methods fit his situation in the best way.

b) It helps him identify the various supply needs for the existing and improved plans.

c) It helps him find out the credit needs, if any, of the new plan.

d) It gives an idea of the expected income after repayment of loans, meeting out the expenditure on production, marketing, consumption, etc.

e) A properly thought of a farm plan might provide cash incomes at points of time when they may be most needed at the farm.

A farm plan is a programme of total farm activities of a farmer drawn out in advance. An optimum farm plan will satisfy all the resource constraints at the farm level and yield the maximum profit.

ii) Characteristics of a Good Farm Plan

A good farm plan generally should have the following characteristics:

a) An element of flexibility in a farm plan is essential to account for changes in the environment around the farm.

b) A farm plan should maximize the resource use efficiency at the farm.

c) It should provide for the attainment of the objectives of profit maximization through optimum resource use and balanced combination of farm enterprises.

d) Risk and uncertainty can be accounted for in a good farm plan.

e) The plan helps in timely acquisition and repayment of farm credit.

iii) Components of Farm Planning: Any systematic farm planning necessarily has the following five components:

a) Statement of the objective function: Many farmers aim at profit maximization. However, some farmers do not go all out to maximize their profits, but have objectives like cereal requirements for the family and fodder needs for the livestock.

b) Inventory of scarce resources and constraints

1) Land: Location, topography, soil type, fertility, drainage, irrigation systems and so on affect enterprises in many ways and hence, it is useful to divide all the land on a farm into different enterprises.

2) Labour: On subsistence farms, all labour is supplied by the farmer and his family. Thus, it is important to record the number of workers - male, female and children - and the type of manual work each is prepared is undertake. However, in commercial farms, hired labour constitutes a major component of costs and thereby inviting more attention in the planning process.

3) Capital: Whether fixed, like buildings and machines, or circulating, like cash in hand or in the bank, capital acts as a very powerful constraint.

4) Personal: Farmers' past experience, attitude towards risks and uncertainties and personal likes and dislikes influence the choice of enterprise.

5) Institutional: Market often serves as a constraint for the production of vegetables, poultry, milk, etc. Even if the location of the farm is suitable for a particular crop (commodity), a contract may still have to be obtained. E.g. Sugarcane growing near the sugar mills. Similarly, though many parts of Himachal Pradesh are suitable for poppy cultivation, the government has banned its cultivation.

6) Rotations: Maximum permissible area under a particular crop in a given season or minimum area constraints imposed on the acre under some crops like legumes would serve in maintaining soil fertility and help controlling pest and diseases.

3) Alternative Choices: Alternative choices in planning refer to the various enterprises, crops and livestock, which can be considered for attaining the stated objectives. There are alternate ways to use the scarce farm resources. There may be more than one ways to produce the same enterprise. A comprehensive list of different alternative enterprises can be prepared.

4) Input Output Co-efficients: The requirements of each of the several scarce resources and the financial returns per unit of each enterprise or activity need to be considered here. The precision in planning depends more on accurate input-output data than on the technique of planning.

5) Planning Technique: With a proper understanding of the planning environment and use of precise input-output data along with true and realistic constraints, sophisticated techniques give better results. However, common sense in the planning process could lead to fairly good results. Some of the farm planning techniques are as listed below:

1. Budgeting.

2. Linear Programming.

Budgeting is most informal of all the planning techniques and the level of sophistication gradually increases as we move from budgeting to linear programming.

iv) Steps in Farm Planning: The various steps involved in planning are discussed below:

a) Planning: This includes the identification and definition of the problem, collection of information, identifying alternative solutions and analyzing each alternative. Planning is the basic management function as it means deciding on a course of action, procedure or policy. The control function is a source of new information, as the results of the initial plan become known.

b) Implementation: Once the planning process is completed, the best alternative must be selected and action should be taken to place the plan into operation. This requires the acquisition and organization of necessary land, labour, capital and other inputs. An important part of the implementation function is the financing of the necessary resources.

c) Control: This provides for observing the results of the implemented plan to see if the specified goals and objectives are being met. Many things can cause a plan to go “off its track”. Price and other changes, which occur after the implementation of the plan, can cause the actual results to deviate from the expected. Control requires a system for making regular checks on the plan and monitoring progress and results as measured against the established goals. The dashed line in the chart represents the continuous flow of information from the

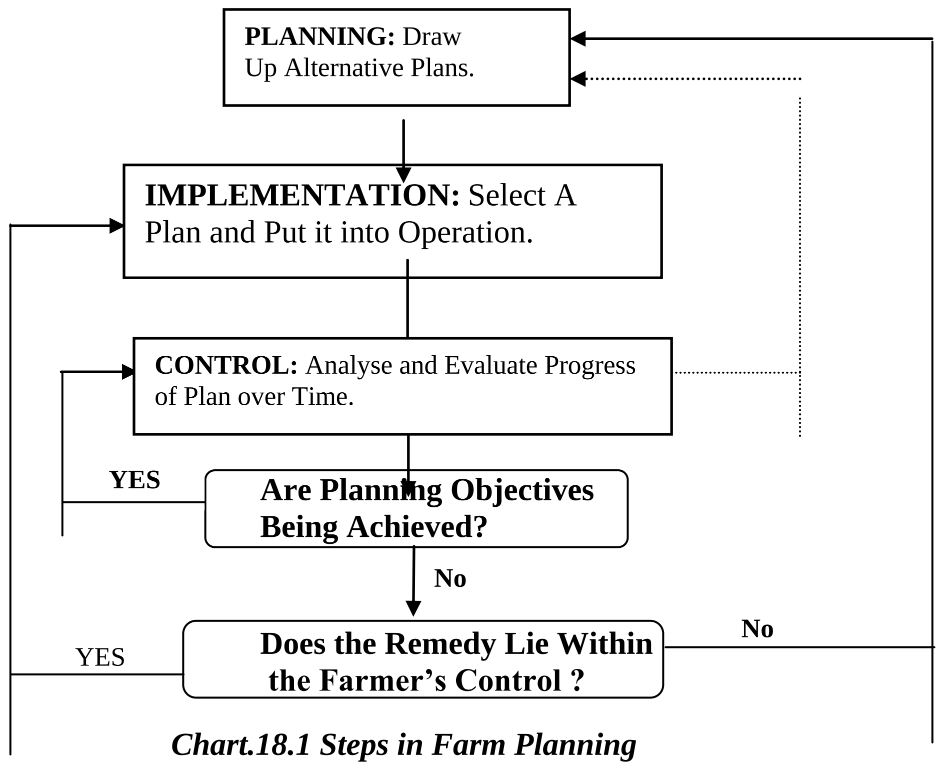


Chart.18.1 Steps in Farm Planning

control function back to planning, an important part of the total system. Without some feedback procedure, the information obtained by the control system is of no use in making corrections in the existing plan or improving future plans. This feedback sets up a continuous cycle of planning, implementation, monitoring and recording progress, followed by a reevaluation of the plan and the implementation procedures using the new information obtained through the control function.

viii) Depreciation

Depreciation is the decline in the value of a given asset as a result of the use, wear and tear, accidental damages and time obsolescence. The loss in value of an asset over time is, therefore, determined by i) remaining life, ii) extent and nature of use and iii) obsolescence. The relative importance of the above factors varies with the kind of assets and the extent to which it is put into use. Depreciation charges may either be spread uniformly over the entire useful life of an asset or they can be relatively heavier during the early life of an asset. The amount of depreciation charged should correspond to the loss in the value of asset over time. The computation of depreciation would not be necessary, if all items purchased were completely worn out by the end of the year of its purchase. However, the items such as buildings, equipments, livestock, etc are used up gradually over a long period of years and an important question arises about the determination of cost of such articles for one specific accounting year.

The span of an asset can be examined in two ways. In developing economies, any asset once acquired remains in use so long as it can be kept in use. But in developed countries, new improved assets, especially machines that provide more efficient and economical services, are continuously developed and the farmer replaces much before its full working life, even while it is in working condition. The “time” depreciation in such cases known as obsolescence is equally important as that of “use” depreciation. While considering life span (or working life) of an asset, the past experience (or experience of the neighbouring farmers) and the expert opinion (of engineers) should be sought. The chance of obsolescence and the residual (or junk or scrap or salvage) value should also be carefully considered. The value of the asset may become completely exhausted or reduced to its junk value at the end of its useful life.

a) Calculation of Depreciation

Depreciation charges are merely a method of distributing the cost of the assets over the period of their use. Both the elements of depreciation, viz., use and time should be considered in working out the depreciation. There are three methods of calculating annual depreciation as discussed below:

1.Straight-Line Method: This method is relatively easy and simple to understand. The annual depreciation of asset is computed by dividing the original cost of the asset less salvage value by the expected years of life.

$$\textbf{Annual Depreciation (AD)} = \frac{\textbf{Original Cost (OC) – Salvage Value (SV)}}{\textbf{Expected Years of Life (EL)}}$$

$$AD = \frac{12000 - 1200}{10} = \text{Rs. 1080 per year.}$$

The life of the asset may be calculated in terms of years (time) or units of production, viz., acres or hours of work. In case of tractor, its life may be 10 years or 10,000 hours of work. The actual depreciation of the asset may not be uniform in value every year during the entire useful life of an asset. It may be more during the early years, when asset depreciates at a faster rate and less in the later years of its life. It can be the other way also. Thus, the straight-line method may not be realistic for the estimation of depreciation of all assets. However, it may be suitable to long lasting assets like buildings and fences, which may require uniform maintenance during their lifetimes.

2.Declining or Diminishing Balance Method: In this method, a fixed rate of depreciation is used every year and applied to the remaining value of the asset at the beginning of each year. It is important to note that salvage value is not subtracted from the original cost as in straight-line method. A fixed rate of depreciation which should be nearly twice that is used under the straight-line method is applied to uncovered balance amount every year until the salvage value is reached and after that no depreciation is worked out. The annual depreciation under this method is estimated as follows:

AD= (OC – D) x R

Where, OC- Original Cost; D – Accumulated depreciation occurred in prior years; and R- Rate of Depreciation.

In this method, the amount of depreciation decreases year after year and ultimately the asset is reduced to its junk value. This method may be suitable to those assets which depreciate at a faster rate in the beginning of their lives. E.g. Tractor, pump-set, etc. Assume a Rs.12,000 worth of an oil engine with an expected life of 10 years and salvage value of Rs.1,200.

The rate of depreciation would obviously be 20 per cent for this method as 10 per cent was used under straight-line method.

3.Sum-of-the-Year Digit Method (or) Reducing Fraction Method: If it is desired to distribute depreciation charges more heavily in the earlier life of an asset and more lightly in the later years, the sum-of-year-digits method can be

AD = (OC – SV)

SD

Table 16.1 Estimation of Annual Depreciation using
Diminishing Balance Method

Year	Value at the Beginning of the Year (Rs)	Annual Depreciation (Rs)	Remaining Balance (Rs)
1	12,000.00	12,000.00x0.2=2,400.00	9,600.00
2	9,600.00	9,600.00x0.2=1,920.00	7,680.00
3	7,680.00	7,680.00x0.2=1,536.00	6,144.00
4	6,144.00	6,144.00x0.2=1,228.80	4,915.20
5	4,915.20	4,915.20x0.2=983.04	3,932.16
6	3,932.16	3,932.16x0.2=786.43	3,145.73
7	3,145.73	3,145.73x0.2=629.15	2,516.58
8	2,516.58	2,516.58x0.2=503.32	2,013.26
9	2,013.26	2,013.26x0.2=402.65	1,610.61
10	1,610.61	1,610.61x0.2=322.12	1,288.49

used. As no undistributed balance is left over in this method, it has an advantage over the diminishing balance method. In case of declining balance method, the value at the end of the useful life is different from the expected salvage value. By this method, the annual depreciation is found out by multiplying a fraction by the amount to be depreciated (original cost minus salvage value).
N – The years of life remaining at the beginning of accounting period.
SD – The sum of the years of life of the asset
In this method, the digits upto the expected life of the asset are added (the digits can be summed

up using a formula i.e., n (n+1) / 2; where n is the total number of years of life). As the value of the fraction N/SD keeps on declining each year, the annual depreciation also declines with the advancement in the age of an asset as in the declining balance method.
Assume an oil engine with the original cost of Rs.12,000, an expected life of 10 years and salvage value of Rs. 1,200. Annual depreciation for this asset over its life can be calculated as shown in the table below:
This method also suits those assets for which relatively higher depreciation needs to be charged during earlier years of their lives. This method differs from the declining balance method in that the rate of decline in depreciation is uniform from year to year whereas in the declining balance method, it keeps on.

Lecture No 17.

Farm Budgeting ? partial, enterprise and complete budgeting.

B. BUDGETING

It may be defined as a detailed physical and financial statement of a farm plan or of a change in farm plan over a certain period of time. Farm budgeting is a method of analyzing plans for the use of agricultural resources at the command of the decision-maker. In other words, the expression of farm plan in monetary terms through the estimation of receipts, expenses and profit is called farm budgeting.

i) Types of Farm Budgeting: The following are the different types of farm budgeting techniques:

a) Partial Budgeting.

b) Enterprise Budgeting.

c) Cash flow Budgeting.

d) Complete Budgeting.

a) Partial Budgeting: This refers to estimating the outcome or returns for a part of the business, i.e., one or few activities. A partial budget is used to calculate the expected change in profit for a proposed change in the farm business. A partial budget contains only those income and expense items, which will change, if the proposed modification in the farm plan is implemented. Only the changes in income and expenses are included and not the total values. The final result is an estimate of the increase or decrease in profit. In order to make this estimate, a partial budget systematically, answers to following four questions relating to the proposed change: 1) What new or additional cost will be incurred? 2) What current income will be lost or reduced? 3) What new or additional income will be received? and 4) What current costs will be reduced or eliminated? The first two questions identify changes which will reduce profit by either increasing costs or reducing income. Similarly, the last two questions identify factors which will increase profit by either generating additional income or lowering costs. The net change in profit can be computed by estimating the total increase in profit minus the total reduction in profit. A positive value indicates that the proposed change in the farm plan will be profitable. All the changes in farm plan that can be appropriately adapted with the help of a partial budget can be grouped into three types. They are as given below:

1) Enterprise substitution: This indicates a complete or partial substitution of one enterprise for another. E.g. substituting one acre of paddy for one acre of sugarcane.

2) Input substitution: Changes involving the substitution of one input for another or the total amount of input to be used are easily analyzed with a partial budget. E.g. substituting machinery for labour.

3) Size or scale of operation: Included in this category would be changes in total size of the farm business or in the size of a single enterprise. E.g. Buying or renting additional land or machinery.

Table 18.1 Introduction of Soyabean as an Intercrop in Sugarcane

Debit (Added Cost)	Amount (Rs)	Credit (Added Return)	Amount (Rs)
1. Increased Cost:	280.00	1. Added Return	1200.00
i) Labour			
ii) Seed	20.00	2. Reduced Cost	-
Sub- Total	300.00	Total	1200.00
2. Reduced Return	-		
Total	300.00		
Net change in income=Added return – Added cost = Rs. 1200 – 300 = Rs. 900			

i) Limitations of partial budgeting technique

1. Partial change does not always provide a complete solution.

2. The results of partial budgets are subject to variations in output - input prices, availability of resources and variations due to soil type, soil fertility etc.

b) Enterprise Budgeting: Enterprise is defined as a single crop or livestock commodity. Most farms consist of a combination of several enterprises. An enterprise budget is an estimate of all income and expenses associated with a specific enterprise and an estimate of its profitability. It is pre-requisite for the preparation of a complete farm budget or for the application of farm planning techniques like linear programming. An enterprise budget lists down all the expected output, both in physical as well as value terms, for a unit of a particular activity (i.e., per hectare, per animal or per 100 birds) on the farm. The enterprise budget is important since it depicts the relative profitability of different enterprises or activities or alternatives, which can be used to determine the relative dominance of different enterprises. It includes variable cost or total operating cost and fixed cost including depreciation and interest on fixed asset. Any enterprise budget can also be analyzed in terms of cash versus non-cash

expenses and total cost versus actual cash outlay.

Table 18.2 Enterprise Budget for Irrigated Ground - Nut

Particulars	Amount (Rs)
I Returns	
1. Main product	6277
2. By product	524
3. Gross return	6801
II Cost	
1. Land revenue	21
2. Seed	1245
3. Manures and fertilizers	530
4. Plant protection chemicals	98
5. Irrigation charges	190
6. Machine power	206
7. Bullock power	304
8. Human labour	1617
9. Interest on working capital	128
10. Depreciation on buildings and machineries	125
11. Interest on Fixed capital	725
Total cost	5189
Net return	1612

c) Cash - Flow Budgeting: It is essential to know about cash flow statement before using the cash flow budgeting.

1) Cash Flow Statement: It summarizes the magnitude of cash inflows and outflows over a period of time.

2) Importance of cash flow Statement: It helps to assess: i) whether cash would be available in correct quantity at right time; ii) whether the surplus could be profitably diverted and iii) timing and magnitude of borrowings required. The cash flow statement may be constructed over annually, quarterly, monthly and weekly depending upon the nature of business.

i) Cash inflows represent the amount of cash received during the particular time period. It includes: a) the beginning cash balance, b) receipts through sales of farm and non-farm assets and c) receipts of short term (operating), intermediate and long term loans.

ii) Cash Outflows represents the expenses incurred in a given period of time. It includes: a) Cash expenses (variable cash expenses, fixed cash expenses, non-farm investment, and personal expenses), b) Repayment on operating (crop) loans and c) repayment on intermediate and long-term loans.

Cash flow analysis indicates the amount of cash flowing into and out of the farm business over a specific period of time. Cash flow statements and income statements both show inflows and outflows of money, but differ in their treatment of several important accounting entries. A cash flow statement includes non-farm items such as income taxes, non-farm income and living expenses and gives a complete accounting of debt transactions by showing principal payments and proceeds of new loans, whereas the income statement shows only interest payments.

3) Cash Flow Budgeting: A cash flow budget is a summary of the cash inflows and outflows for a business over a given time period. As a forward planning tool, its primary purpose is to estimate future borrowing needs and the loan repayment capacity of the business. Cash flow budgeting is to assess the whole farm plan.

Table 18.3 Simplified Cash-Flow Budget

(Amount in Rs)

Particulars	**Time Period I**	**Time Period II**
1. Beginning cash balance	1000	1000
Cash inflow		
2. Farm products sales	2000	12000
3. Capital sales	0	4500
4. Miscellaneous cash income	0	500
5. Total cash inflow	3000	18000
Cash outflow		
6. Farm operating expenses	3500	1800
7. Capital purchases	10000	0
8. Miscellaneous expenses	500	200
9. Total cash outflow	14000	2000
10. Cash balance (5 – 9)	- 11000	16000
11. Borrowed funds needed	12000	0
12. Loan repayment (principal and interest)	0	12720
13. Ending cash balance (10 + 11 – 12)	1000	3280
14. Debt outstanding	12000	0

Here, two time periods are considered. In the time period I, there is Rs.3,000 cash inflow and Rs.14,000 cash outflow, leaving a projected cash balance of - Rs.11,000. This would require a borrowing of Rs.12,000 to permit Rs.1000 minimum ending cash balance. The total cash outflow in the period II is Rs.18,000 which leaves a projected cash balance of Rs.16,000 and it permits paying off the debt incurred in period I, estimated at Rs.12,720 when interest is included. The final result is an estimated Rs.3,280 cash balance at the end of second period. The primary use of a cash flow budget is to project the timing and amount of new borrowing; the business will need during the year and the timing and amount of loan repayments.

d) Complete or Whole Farm Budgeting: It is a technique for assembling and organizing the information about the whole farm in order to facilitate decisions

Table 18.4 Complete Budget Showing Projected Income, Expenses and Profit.

Particulars	Amount (Rs)
I Income: i) Cotton	54,000
ii) Paddy	43,000
iii) Sorghum	13,500
iv) Dairy products	40,000
Total income	150,500
II Variable Expenses: i) Fertilizers	11,900
ii) Seeds	3,600
iii) Plant protection chemicals	7,900
iv) Fuel and oil	4,050
v) Machine repairs	2,650
vi) Feed purchase	1,600
vii) Veterinary expenses and other expenses	30,100
viii) Custom hire charges	10,250
ix) Miscellaneous expenses	2,450
Total variable Expenses	74,500
III Fixed Expenses: i) Tax	2,600
ii) Insurance	1,250
iii) Interest on debt	22,000
iv) Machinery depreciation	7,200
v) Building depreciation	3,200
Total fixed expenses	36,250
Total expenses	110,750
Net Farm Income (Rs. 150,750 – 110,750)	39,750

about the management of farm resources. It attempts to estimate all items of costs and returns and it presents a complete picture of farm business. It is generally used by beginners or by those farmers who want to completely overhaul their existing farm organization and operation. Complete and partial budgeting are mutually complementary, i.e., the partial budgeting should be used at various stages of complete budgeting in order to decide the changes to be effected in the farm organization. The process of complete budgeting involves: i) appraisal of existing farm resources, their uses and efficiency, ii) appraisal of alternatives or opportunities or various production activities that can be included and their resource requirements and iii) preparing and evaluating the alternative plans for their feasibility and profitability. The above table shows an estimated profit or net farm income of Rs.39,750, if the prices and yield are actually realized. Changes in any of these factors will obviously affect the actual profit received from operating the farm under this plan.

1) Uses: i) It provides a basis for comparing alternative plans for profitability. This can be particularly useful when planning is carried out for growth and expansion.

ii) A detailed whole farm budget showing the estimated profit can be used to borrow the necessary operating capital.

2) Complete Budgeting and Partial Budgeting: The difference between these two are: i) Complete budgeting accounts for drastic changes in the organization and operation of the farm, while partial budgeting treats minor changes only. ii) All the available alternatives are considered in complete budgeting, whereas partial budget considers two or a few alternatives only. iii) Complete budgeting is used for estimating the results of entire organization and operation of a farm, while partial budget helps only to study the net effects in terms of costs and returns of relatively minor changes.

e) Linear Programming: George Dantzing (1947) developed the simplex method for optimal transport of ammunition quickly with minimum cost. Linear programming is a mathematical method of analysis, which finds the “best” or optimal combination of business activities to meet a certain objective. Three components are needed to solve a problem with linear programming technique. They are: 1) a desire to maximize or minimize some objective, 2) a set of activities or processes available to accomplish this objective and 3) a set of constraints or restrictions that limit one’s ability to achieve this objective.

1) Basic assumptions of Linear Programming

i) Proportionality or linearity: Linear relationship exists between activity and resource. For example, if one acre requires 30 man days, 100 Kgs of nitrogen and Rs.60 of other variable expenses to produce 20 quintals of maize output, then 10 acres of maize would require exactly 10 times of each resource to produce 200 quintals of output.

ii) Additivity: The total amount of resources used by several enterprises on the farm must be equal to the sum of resources used by each individual enterprise. Hence no interaction is possible. The same is true for the products also.

iii) Divisibility: Fractions can be used and enterprises can be produced in fractional units. Resources and products are infinitely divisible.

iv) Non-negativity: None of the activity is negative.

v) Finiteness: Number of activities and constraints are finite.

vi) Certainty: Almost all planning techniques assume that resources, supplies, input - output coefficients and prices are known with certainty.

2) Concepts used in Linear Programming

i) Solution: A solution refers to any set of activities Xj, j = 1, 2, 3, ..., n, which satisfies a system of inequality constraints. There may be innumerable solutions to a given linear programming problem.

ii) Feasible Solution: Any solution to a linear programming problem is said to be feasible, if none of the Xj is negative.

iii) Infeasible Solution: It refers to a solution, where some of the variables, Xjs, appear at a negative level.

iv) Optimum Solution: One of the feasible solutions is optimum, provided a feasible solution exists. Such a feasible solution, which optimizes the objective function, is called an optimum solution. The set of Xj in this case satisfies the set of constraints and non-negativity restrictions and also maximizes the objective function.

v) Unbounded Solution: Many a time, faulty formulation of a linear programming problem may result in an arbitrarily large value of the objective function and the problem has no finite maximum value of profit. It represents a case of unbounded solution to a linear programming problem.

3) Estimation of Optimum Solution using Linear Programming: The estimation of optimal solution using linear programming is given in table 18.5.

Table 18.5 (a) Estimation of Optimum Solution using Linear Programming

Particulars	Per Acre of Paddy	Per Acre of Ground-Nut
Income and Expenses		
1. Gross income	2600	2000
2. Total cost	1100	600
3. Net income	1500	1400
Resource Requirements		
1. Acres of crop- land	1	1

2. Hours of labour during harvesting	45	60
3. Rupees of operating capital	1100	600

Table 18.5 (b) Estimation of Optimum Solution using Linear Programming

Particulars	**Amount Available**	**Paddy**		**Ground-nut**	
		Per Acre Needs	**Maximum Area (Acres) Required**	**Per Acre Needs**	**Maximum Area (Acres) Required**
1. Maximum land.	4 acres	1	4.00	1	4.00
2. Maximum hours.	225 hours	45	5.00	60	3.75
3.Maximum operating capital.	Rs. 3500	1100	3.18	600	5.83

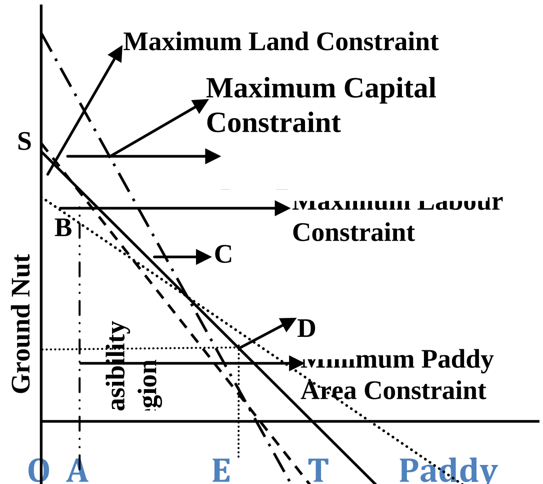


Fig.18.1 Estimation of Optimum Solution using Linear Programming Technique

There is also one additional restriction the farmer wants to incorporate into the analysis. He wants a farm plan that has at least 0.7 acres of paddy. The line that connects points A, B, C, D and E in the figure 18.1 defines an area which contains all numerous combinations of paddy and groundnut that can be produced on this farm. This region is called the feasible region of production. At any point outside this line, the farmer could not produce that combination of paddy or groundnut without isolating any one of the constraints.

In order to complete the graphic analysis, it is necessary to find out the optimal combination of paddy and groundnut that maximizes the net return to the fixed resources of land, labour and operating capital and minimum acreage requirements. This is done by defining a line that will give a constant amount of net revenue, given different acreage combinations of paddy and groundnut. The slope of the iso revenue line is calculated by the following equation:

$$\textbf{Slope of Isorevenue Line} = \frac{\textbf{Net Revenue for Paddy}}{\textbf{Net Revenue for Ground Nut}} = \frac{1500}{1400} = 1.071$$

Since the iso revenue line indicates a set of net revenues, it is the farmer's desire to find an iso revenue line as far away from the origin as possible. The farther away the iso revenue line, the greater the net income. In addition, he needs to be concerned that the iso revenue line is within the feasible region of production. The iso revenue line S and T fulfils both of these requirements. Thus, the production levels indicated at corner point D achieves the maximum level of net Income.

Table 18.6 Optimum Solution Using Graphical Method of Linear Programming

Particulars	**Non Optimal Plans**				**Optimal Plan**
	A	**B**	**C**	**E**	**(D)**
1. Acres of Paddy	0.70	0.70	1.00	3.18	2.20
2. Acres of ground nut	0.00	3.23	3.00	0.00	1.80
3. Total net income (Rs)	1050	5565	5700	4770	5820
4. Total crop land used	0.70	3.93	4.00	3.18	4.00
5. Total harvesting labour used	31.5	225	225	143	207
6. Total operating capital used	770	2705	2900	3500	3500

The optimal plan is growing of 2.20 acres of paddy and 1.80 acres of groundnut. It has a total net income of Rs.5620. This plan utilizes all the 4 acres of crop land and Rs.3500 of capital. However, not all labour is used in this plan, with 18 hours being unused (225 - 207). The non-optimal plans like A, B, C and E have lesser net income than that of optimal plan (D).

4) Limitations of Linear Programming

i) Computational difficulties are enormous (unbounded solution may occur)

ii) It does not take into account the time.

iii) Several real world situations are non-linear and in Linear Programming, only linear equations are solved.

iv) Application of Linear Programming to the macro model is very difficult. Rounding up of the solutions of variable will alter the value of optimal solution.