ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRICULTURAL ECONOMICS

LECTURE NOTES

Course No. AECO 241

Farm Management and Production Economics (1+1)

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AECO 241 – FARM MANAGEMENT AND PRODUCTION ECONOMICS 2(1+1)

THEORY

Sl No.	Topic
1	Farm management - Meaning – Definitions of Farm Management – Scope of Farm Management – Relationship with other science
2	Economic principles applied to the organization of farm business – principles of variable proportions – Determination of optimum input and optimum output
3	Minimum loss principle (cost Principle) – Principle of Factor substitution – principle of product substitution
3	Law of Equi-marginal returns – Opportunity cost principle – Principle of Comparative advantage – Time comparison principle
4	Type of farming – Specialization, Diversification, Mixed farming, Dry farming and Ranching – Systems of farming -co-operative farming, Capitalistic farming, collective farming, State farming and Peasant farming
6	Farm planning – Meaning – Need for farm planning – Types of Farm plans – simple farm plan and whole farm plan – characteristics of a good farm plan – basic steps in farm planning
7	Farm budgeting – meaning – types of farm budgets – Enterprise budgeting – Partial budgeting and whole farm budgeting. Linear programming – Meaning- Assumptions – Advantages and limitations
8	Distinction between risk and uncertainty – sources of risk and uncertainty – production and technical risks – Price or marketing risk – Financial risk – methods of reducing risk
9	Agricultural Production Economics – Definitions – Nature – Scope and subject matter of Agricultural Production Economics – Objectives of Production Economics – Basic Production Problems
10	Law of Returns – Law of constant returns – law of increasing returns – law of decreasing returns.
11	Factor – product relationship – Law of Diminishing returns – Three stages of production function – Characteristics – Elasticity of Production
12	Factor – Factor relationship – Isoquants and their characteristics – MRTS – Types of factor substitution
13	Iso –cost lines – Characteristics – Methods of Determining Least-cost combination of

resources – Expansion path – Isoclines – Ridge lines

14 Product – product relationship – product possibility curves – Marginal rate of product substitution – Types of enterprise relationships – Joint products -Complementary - Supplementary – Competitive and Antagonistic products

15 Iso – revenue line and characteristics – Methods of determining optimum combination of products – Expansion path – Ridge lines

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PRACTICALS

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6	Determination of optimum combination of products
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8	Computation of cost concepts related to farm management
9	Farm inventory
10	Methods of computing depreciation
11– 12	Farm financial analysis – preparation of Net worth statement and its analysis
13– 14	Preparation of farm plans and budgets – Enterprise and partial budget
15	Visit to college farm
16	Final Practical Exam

REFEERENCES

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FARM MANAGEMENT

Meaning

Farm Management comprises of two words i.e. Farm and Management.

Farm means a piece of land where crops and livestock enterprises are taken up under common management and has specific boundaries.

Farm is a socio economic unit which not only provides income to a farmer but also a source of happiness to him and his family. It is also a decision making unit where the farmer has many alternatives for his resources in the production of crops and livestock enterprises and their disposal. Hence, the farms are the micro units of vital importance which represents centre of dynamic decision making in regard to guiding the farm resources in the production process.

The welfare of a nation depends upon happenings in the organisation in each farm unit. It is clear that agricultural production of a country is the sum of the contributions of the individual farm units and the development of agriculture means the development of millions of individual farms.

Management is the art of getting work done out of others working in a group.

Management is the process of designing and maintaining an environment in which individuals working together in groups accomplish selected aims.

Management is the key ingredient. The manager makes or breaks a business. Management takes on a new dimension and importance in agriculture which is mechanised, uses many technological innovations, and operates with large amounts of borrowed capital.

The prosperity of any country depends upon the prosperity of farmers, which in turn depends upon the rational allocation of resources among various uses and adoption improved technology. Human race depends more on farm products for their existence than anything else since food, clothing – the prime necessaries are products of farming industry. Even for industrial prosperity, farming industry forms the basic infrastructure. Thus the study farm management has got prime importance in any economy particularly on agrarian economy.

DEFINITIONS OF FARM MANAGEMENT.

1. The art of managing a Farm successfully, as measured by the test of profitableness is called farm management. (L.C. Gray)
2. Farm management is defined as the science of organisation and management of farm enterprises for the purpose of securing the maximum continuous profits. (G.F. Warren)
3. Farm management may be defined as the science that deals with the organisation and operation of the farm in the context of efficiency and continuous profits. (Efferson)
4. Farm management is defined as the study of business phase of farming.
5. Farm management is a branch of agricultural economics which deals with wealth earning and wealth spending activities of a farmer, in relation to the organisation and operation of the individual farm unit for securing the maximum possible net income. (Bradford and Johnson)

NATURE OF FARM MANAGEMENT.

Farm management deals with the business principles of farming from the point of view of an individual farm. Its field of study is limited to the individual farm as a unit and it is interested in maximum possible returns to the individual farmer. It applies the local knowledge as well as scientific finding to the individual farm business.

Farm management in short be called as a science of choice or decision making.

SCOPE OF FARM MANAGEMENT.

Farm Management is generally considered to be MICROECONOMIC in its scope. It deals with the allocation of resources at the level of individual farm. The primary concern of the farm management is the farm as a unit.

Farm Management deals with decisions that affect the profitability of farm business. Farm Management seeks to help the farmer in deciding the problems like what to produce, buy or sell, how to produce, buy or sell and how much to produce etc. It covers all aspects of farming which have bearing on the economic efficiency of farm.

RELATIONSHIP OF FARM MANAGEMENT WITH OTHER SCIENCES.

The Farm Management integrates and synthesises diverse piece of information from physical and biological sciences of agriculture.

The physical and biological sciences like Agronomy, animal husbandry, soil science, horticulture, plant breeding, agricultural engineering provide input-output relationships in their respective areas in physical terms i.e. they define production possibilities within which various choices can be made. Such information is helpful to the farm management in dealing with the problems of production efficiency.

Farm Management as a subject matter is the application of business principles n farming from the point view of an individual farmer. It is a specialised branch of wider field of economics. The tools and techniques for farm management are supplied by general economic theory. The law of variable proportion, principle of factor substitution, principle of product substitution are all instances of tools of economic theory used in farm management analysis.

Statistics is another science that has been used extensively by the agricultural economist. This science is helpful in providing methods and procedures by which data regarding specific farm problems can be collected, analysed and evaluated.

Psychology provides information of human motivations and attitudes, attitude towards risks depends on the psychological aspects of decision maker.

Sometimes philosophy and religion forbid the farmers to grow certain enterprises, though they are highly profitable. For example, islam prohibits muslim farmer to take up piggery while Hinduism prohibits beef production.

The various pieces of legislation and actions of government affect the production decisions of the farmer such as ceiling on land, support prices, food zones etc.

The physical sciences specify what can be produced; economics specify how resources should be used, while sociology, psychology, political sciences etc. specify the limitations which are placed on choice, through laws, customs etc.

ECONOMIC PRINCIPLES APPLIED TO FARM MANAGEMENT.

The outpouring of new technological information is making the farm problems increasingly challenging and providing attractive opportunities for maximising profits. Hence, the application of economic principles to farming is essential for the successful management of the farm business.

Some of the economic principles that help in rational farm management decisions are:

1. Law of variable proportions or Law of diminishing returns: It solves the problems of how much to produce ? It guides in the determination of optimum input to use and optimum output to produce.. It explains the one of the basic production relationships viz., factor-product relationship
2. Cost Principle: It explains how losses can be minimized during the periods of price adversity.
3. Principle of factor substitution: It solves the problem of 'how to produce?. It guides in the determination of least cost combinations of resources. It explains facot-factor relationship.
4. Principle of product substitution: It solves the problem of 'what to produce?'. It guides in the determination of optimum combination of enterprises (products). It explains Product-product relationship.
5. Principle of equi-marginal returns: It guides in the allocation of resources under conditions of scarcity.
6. Time comparison principle: It guides in making investment decisions.
7. Principle of comparative advantage: It explains regional specialisation in the production of commodities.

LAW OF VARIABLE PROPORTIONS OR LAW OF DIMINISHING RETURNS
OR
PRINCIPLE OF ADDED COSTS AND ADDED RETURNS

The law of diminishing returns is a basic natural law affecting many phases of management of a farm business. The factor product relationship or the amount of resources that should be used (optimum input) and consequently the amount of product that should be produced (optimum output) is directly related to the operation of law of diminishing returns.

This law derives its name from the fact that as successive units of variable resource are used in combination with a collection of fixed resources, the resulting addition to the total product will become successively smaller.

Most Profitable level of production

(a) How much input to use (Optimum input to use).The determination of optimum input to use.

An important use of information derived from a production function is in determining how much of the variable input to use. Given a goal of maximizing profit, the farmer must select from all possible input levels, the one which will result in the greatest profit.

To determine the optimum input to use, we apply two marginal concepts viz: Marginal Value Product and Marginal Factor Cost.

Marginal Value Product (MVP): It is the additional income received from using an additional unit of input. It is calculated by using the following equation.

Marginal Value Product = ? Total Value Product/? input level

MVP = ? Y. P_y/? X

? Change

Y =Output

P_y = Price/unit

Marginal Input Cost (MIC) or Marginal Factor Cost (MFC): It is defined as the additional cost associated with the use of an additional unit of input.

Marginal Factor Cost = ? Total Input Cost/? Input level

MFC or MIC = ? X P_x/? X = ? X .Px / ? x = Px

X input Quantity

P_x Price per unit of input

MFC is constant and equal to the price per unit of input. This conclusion holds provided the input price does not change with the quantity of input purchased.

Decision Rules:

1. If MVP is greater than MIC, additional profit can be made by using more input.
2. If MVP is less than MIC, more profit can be made by using less input.
3. Profit maximizing or optimum input level is at the point where MVP=MFC

$(? Y/? X) . P_y = P_x ? Y/? X = P_x/ P_y$

Determination of optimum input level – Example

Input price: Rs.12 per unit, Output price: Rs.2 per unit

Input level X	TPP	MPP	TVP (Rs)	MVP (Rs)	MIC (Rs)
0	0	–	--	--	--
1	12	12	24	24	12
2	30	18	60	36	12
3	44	14	88	28	12
4	54	10	108	20	12
5	62	8	124	16	12
6	68	6	136	12	12
7	72	4	144	8	12
8	74	2	148	4	12
9	72	-2	144	-4	12
10	68	-4	136	-8	12

The first few lines in the above table show that MVP to be greater than MIC. In other words, the additional income received from using additional unit of input exceeds the additional cost of that input. Therefore additional profit is being made. These relationships exist until the input level reaches 6 units. At this input level MVP=MFC. Using more than 6 units of input causes MVP to be less than MFC which causes profit to decline as more input is used. The profit maximizing input level is therefore, at the point where MVP=MIC. Note that the profit maximizing point is not at the input level which maximizes TVP. Profit is maximized at a lower input level.

(b) <u>How much output to produce (Optimum output):</u> The determination of optimum output to produce.

To answer this question, requires the introduction of two new marginal concepts.

Marginal Revenue (MR): It is defined as the additional income from selling additional unit of output. It is calculated from the following equation

Marginal Revenue = Change in total revenue / Change in Total Physical Product

MR = ? TR / ? Y

MR=? Y_y / ? Y

= P_y

Y = output

P_y = price per unit of output

Total Revenue is same as Total Value Product. MR is constant and equal to the price per unit of output.

Marginal Cost (MC): It is defined as the additional cost incurred from producing an additional unit of output. It is computed from the following equation.

Marginal Cost=Change in Total Cost / Change in Total Physical Product

MC=? X. P_x/? Y

X= Quantity of input

P_x= Price per unit of input.

Decision Rules:

1. If Marginal Revenue is greater than Marginal Cost, additional profit can be made by producing more output.

2. If Marginal Revenue is less than Marginal Cost, more profits can be made by producing less output.

3. The profit maximizing output level is at the point where MR=MC

? Y. P_y/? Y=? X. P_x/? Y

P_y = ? X. P_x/? Y

? Y. P_y = ? X. P_x

Determination of Optimum output to produce: **(An example)**

Input Price Rs.2 per unit output price Rs.2 per unit

Input level X	TPP	MPP	TR (Rs)	MR (Rs)	MC (Rs)
0	0	-	-	--	--
1	12	12	24	2.00	1.00
2	30	18	60	2.00	0.67
3	44	14	88	2.00	0.86
4	54	10	108	2.00	1.20
5	62	8	124	2.00	1.50
6	68	6	136	2.00	2.00
7	72	4	144	2.00	3.00
8	74	2	148	2.00	6.00
9	72	-2	144	2.00	
10	68	-4	136	2.00	

In the above table, it is clear that MR is greater than MC up to the output level 62 units. At the output level of 68 units, the MR=MC. This is the optimum output to be produced. If we produce 72 units of output, additional revenue from additional output is less than the additional cost of producing output. Therefore profit decline.

COST PRINCIPLE OR MINIMUM LOSS PRINCIPLE:

This principle guides the producers in the minimization of losses.

Costs are divided into fixed and variable costs. Variable costs are important in determining whether to produce or not . Fixed costs are important in making decisions on different practices and different amounts of production.

In the short run, the gross returns or total revenue must cover the total variable costs (TVC). To state in a different way that selling price must cover the average variable cost (AVC) to continue production in the short run.

In the long run, gross returns or total revenue must cover the total cost (TC). Alternatively stated, that the selling price must cover cost of production (ATC).

In the short run MR = MC point may be at a level of output which may involve loss instead of profit. The situation of operating the farms when the price of product (MR) is less than average total cost (ATC) but greater than average variable

cost (AVC) is common in agriculture. This explains why the farmers keep farming even when they run into losses.

PROFIT OR DECISION RULES

SHORT RUN:

1. If expected selling price is greater than minimum average total cost (ATC), profit is expected and is maximized by producing where MR = MC.
2. If expected selling price is less than minimum average total cost (ATC) but greater than minimum average variable cost (AVC), a loss is expected but the loss is less than TFC and is minimized by producing where MR = MC.
3. If expected selling price is less than minimum average variable cost (AVC), a loss is expected but can be minimized by not producing anything. The loss will be equal to TFC.

LONG RUN

1. Production should continue in the long run when the expected selling price is greater than minimum average total cost (ATC).
2. Expected selling price which is less than minimum ATC result in continuous losses. In this case, the fixed assets should be sold and money invested in more profitable alternative.

The following example illustrates the operation of cost principle.

Cost of cultivation of groundnut	**(Rs./ha)**
Total variable costs	2621.00
Total fixed costs	707.00
Total costs	3328.00
Yield (quintals)	9
Average variable cost	291
Average total cost	369.77
Selling price	18430
Gross returns	3870
Net returns	542
Suppose the price declines to	350
Gross returns	3150
Net income	-178

If the price of groundnut per quintal is Rs. 430, for 9 quintals, farmer gets Rs. 3870 as gross income. The net income is Rs. 542 (Rs. 3870 – Rs. 3328). Suppose the price decline to Rs. 350 per quintal the net income would be Rs. 178 (Rs 3150 – Rs. 3870). Now the question is whether the farmer should continue the production or not at the price of Rs. 350.

If the farmer does not operate the farm the loss would be Rs. 707 in the form of fixed costs. If farm is operated, gross income of Rs. 3150 exceeds the variable costs (Rs. 2621) by Rs. 529. By this amount the loss of Rs. 707 on account of fixed cots gets reduced i.e., (Rs. 707-529 = Rs. 178). The loss would be reduced to Rs. 178 by operating the farm.

PRINCIPLE OF FACTOR SUBSTITUTION

This economic principle explains one of the basic production relationships viz., factor factor relationship. It guides in the determination of least cost combination of resources. It helps in making a management decision of how to produce.

Substitution of one input for another input occurs frequently in agricultural production. For example, one grain can be substituted for another or forage for grain in livestock ration, chemical fertilizers can be substituted for organic manure, machinery for labour, herbicides for mechanical cultivation etc. the farmer must select that combination of inputs or practices which will produce a given amount of output for the least cost. In other words, the problem is to find the least cost combination of resources, as this will maximize profit from producing a given amount of output.

The principle of factor substitution says that go on adding a resource so long as the cost of resource being added is less than the saving in cost from the resource being replaced. Thus if input X_1 is being increased, and input X_2 is being replaced, increase the use of X_1 so long as.

Decrease in cost	>	Increase in cost
Quantity saved of the replaced input ? price per unit of replaced input	>	Quantity increased of the added input ? Price per unit of added input
i.e., $\frac{\text{Quantity saved of the replaced input}}{\text{Quantity increased of the added input}}$	>	$\frac{\text{Price per unit of added input}}{\text{Price per unit of replaced input}}$
i.e. MRS	>	PR

Profit or Decision rules:

1. If Marginal rate of substitution (MRS) is greater than price ratio (PR) costs can be reduced by using more of added resource.

$$\frac{?X_2}{?X_1} > \frac{PX_1}{PX_2}$$ increase the use of X_1

or

$$\frac{?X_1}{?X_2} > \frac{PX_2}{PX_1}$$ increase the use of X_2

2. If Marginal rate of substitution (MRS) is less than price ratio (PR), costs can be reduced by using more replaced resource.

$$\frac{?X_2}{?X_1} < \frac{PX_1}{PX_2}$$ increase the use of X_2

or

$$\frac{?X_1}{?X_2} < \frac{PX_2}{PX_1}$$ increase the use oif X_1

3. Least cots combination of resources is at the point where MRS=PR

$$\frac{?X_2}{?X_1} = \frac{PX_1}{PX_2}$$

or

$$\frac{?X_1}{?X_2} = \frac{PX_2}{PX_1}$$

Example : Selecting a Least-cost feed ratio :
(Price of grain: Rs.4.40 per kg , price of hay : Rs.3/- per kg)

Grains in kgs (X_1)	Hay in kgs (X_2)	ΔX_1	ΔX_2	MRS	PR
825	1350	-	-	-	-
900	1130	75	220	2.93	1.47
975	935	75	195	2.60	1.47
1050	770	75	165	2.20	1.47
1125	630	75	140	1.87	1.47
1200	520	75	110	**1.47**	**1.47**
1275	440	75	80	1.07	1.47

The least cost combination of grain and hay is a combination of 1200 kgs of grain and 520 kgs of hay, as the substitution ratio equals price ratio.

LAW OF EQUI-MARGINAL RETURNS

Most of the farmers have limited resources. They have limited land, limited capital, limited irrigation facilities. Even the labour which is considered to be surplus becomes scarce during peak sowing, weeding and harvesting periods. Under such resource limitations, farmers must decide how a limited amount of input should be allocated or divided among many possible uses or alternatives. For example farmer has to decide on the best allocation of fertilizer between different crops and feed between different types of livestock. In addition, limited capital must be allocated to the purchase of fertilizers, seeds, feed etc.

The equi-marginal principle provides guidelines for the rational allocation of scare resources. The principle says that returns from the limited resources will be maximum if each unit of the resource should be used where it brings greatest marginal returns.

Statement of the law

A limited input should be allocated among alternative uses in such a way that the marginal value products of the last unit are equal in all its uses.

Example

A farmer has Rs. 3000/- and wants to grow sugarcane, wheat and cotton. What amount of money be spent on each enterprise to get maximum profits.

Amount (Rs.)	**Marginal value products from**		
	Sugarcane (Rs.)	**Wheat (Rs.)**	**Cotton (Rs.)**
500	800 (1)	750 (2)	650 (6)
1000	700 (3)	650 (5)	560
1500	650 (4)	580	550
2000	640	540	510
2500	630	520	505
3000	605	510	500

The first Rs. 500 would be allocated to sugarcane as it has the highest MVP. The second dose of Rs. 500 would be allocated to wheat as its MVP is higher than that of

cotton and sugarcane. In the same way, third would be used on sugarcane, the fourth, fifth and the sixth on sugarcane, wheat and cotton respectively. Each successive Rs of 500 is allocated to the crop which has highest marginal value product remaining after previous allocation.

The final allocation is Rs. 1500 on sugarcane, Rs 1000 on wheat and Rs. 500 on cotton.

OPPORTUNITY COST

It is an economic concept closely related to the equi-marginal principle. Opportunity cost recognizes the fact that every input has an alternative use. Once an input is committed to a particular use, it is no longer available for any other alternative use and the income from the alternative must be foregone.

Definition : Opportunity cost is defined as the returns that are sacrificed from the next best alternative.

Opportunity cost is also known as **real cost or alternate cost**.

PRINCIPLE OF PRODUCT SUBSTITUTION

This principle explains the product-product relationship and helps in deciding the optimum combination of products. Also, this economic principle guides in making a decision of what to produce.

It is economical to substitute one product for another product, if the decrease in returns from the product being replaced is less than the increase in returns from the product being added.

The principle of product substitution says that we should go on increasing the output of a product so long as decrease in the returns from the product being replaced is less than the increase in the returns from the product being added.

Decrease in returns	<	Increase in returns
Quantity of output reduced of replaced product ? price per unit of replaced product	<	Quantity of output increased of added product ? Price per unit of added product

$$\text{i.e. } \frac{\text{Quantity of output reduced of replaced product}}{\text{Quantity of output increased of added product}} < \frac{\text{Price per unit of added product}}{\text{Price per unit of replaced product}}$$

i.e. MRS < PR

Profit rules or Decision rules:

1. If MRS < PR, profits can be increased by producing more of added product.

$$MRS_{Y1, Y2} = \frac{\Delta Y_2}{\Delta Y_1} < \frac{P_{Y_1}}{P_{Y_2}} \text{ increase } Y_1$$

$$MRS_{Y_2, Y_1} = \frac{\Delta Y_1}{\Delta Y_2} < \frac{P_{Y_2}}{P_{Y_1}} \text{ increase } Y_2$$

2. MRS > PR, profits can be increased by producing more of replaced product.

$$MRS_{Y_1, Y_2} = \frac{\Delta Y_2}{\Delta Y_1} > \frac{P_{Y_1}}{P_{Y_2}} \text{ increase } Y_2$$

$$MRS_{Y_2, Y_1} = \frac{\Delta Y_1}{\Delta Y_2} > \frac{P_{Y_2}}{P_{Y_1}} \text{ increase } Y_1$$

3. Optimum combination of products is when MRS= PR

$$\frac{\Delta Y_2}{\Delta Y_1} = \frac{P_{Y_1}}{P_{Y_2}}$$

or

$$\frac{\Delta Y_1}{\Delta Y_2} = \frac{P_{Y_2}}{P_{Y_1}}$$

Example : Selecting an optimum combination of enterprises

(P_{Y1} = Rs. 280 per quintal; P_{Y2} = Rs. 400 per quintal)

Y_1 (Quintals)	**Y_2 (Quintals)**	ΔY_1	ΔY_2	**MRS $_{Y1, Y2}$**	**PR**	**Decrease in returns**	**Increase in returns**
0	60	-	-	-	-	-	-
20	56	20	4	0.20	0.70	1600	5600
40	50	20	6	0.30	0.70	2400	5600
60	41	20	9	0.45	0.70	3600	5600
80	30	20	11	0.55	0.70	4400	5600
100	16	20	14	0.70	0.70	5600	5600
120	0	20	16	0.80	0.70	6400	5600

It can be seen from the above table that upto fifth combination MRS is less than PR. But at the sixth combination MRS is equal to PR. Therefore, the sixth combination which produces 100 qunitals of corn Y_1 and 16 qunitals of wheat Y_2 is the optimum or profit maximizing combination.

PRINCIPLE OF COMPARATIVE ADVANTAGE

Certain crops can be grown in only limited areas because of specific soil and climatic requirements. However, even those crops and livestock enterprises which can be raised over a broad geographical area often have production concentrated in one region. Farmers in Punjab specialize in wheat production while farmers in Andhra Pradesh specialize in paddy production. These crops can be grown in each state. Regional speciation in the production of agricultural commodities and other products can be explained by the principle of comparative advantage.

While crops and livestock products can be raised over a broad geographical area, the yields, production costs, profits may be different in each area. It is relative yields, costs, and profits which are important for the application of this principle.

Statement of the principle

Individuals or regions will tend to specialize in the production of those commodities for which their resources give them a relative or comparative advantage.

The following example illustrates the principle of comparative advantages.

Crop account per acre	**Region A**		**Region B**	
	Wheat	**Groundnut**	**Wheat**	**Groundnut**
Total Revenue (Rs.)	500	225	225	220
Total Cost (Rs.)	425	200	210	200
Net Returns (Rs.)	75	25	15	20
Returns per rupee	1.18	1.13	1.07	1.10

Region A has greater absolute advantage in growing both wheat and groundnut than Region B because the net incomes per acre are Rs. 75 and Rs. 25 respectively which are higher than the net incomes from wheat and groundnut in Region B. Farmers of Region A can make more profits by growing both the crops. But they want to make the greatest profits and this can be done by having the largest possible acreage under wheat alone as it is the question of relative advantage. Similarly farmers of Region B have relative advantage in growing groundnut.

TIME COMPARISON PRINCIPLE

Many farm decisions involve time. For example, a farmer has to decide between a cereal crop which would be harvested after about four months or an orchard which would start giving returns after three years. Further, a farmer has to decide whether to purchase new farm machinery with 10 years of life or a second hand one which may have only five years of life. Several other decisions involving time and initial capital investment could be judiciously taken by compounding or discounting.

Future value of a present sum:

The future value of money refers to the value of an investment at a specified date in the future.

This concept assumes that investment will earn interest which is reinvested at the end of each time period to also earn interest. The procedure for determining the future value of present sum is called **compounding** .

The formula to find the future value of present sum in given below

$FV = P (1 + i)^n$

where,

FV = Future value;

P = the present sum,

i = the interest rate,

n = the number of years.

Example:

Assume you have invested Rs. 100 in a savings account which earns 8% interest compounded annually and would like to know the future value of this investment after 3 years.

Year	**Value at beginning of year (Rs.)**	**Rate of interest**	**Interest earned (Rs.)**	**Value at the end of the year (Rs.)**
1	100	8%	8.00	108.00
2	108	8%	8.64	116.64
3	116.64	8%	9.33	125.97

In the example, a present sum of Rs. 100 has a future value of Rs. 125.97 when invested at 8 per cent interest for 3 years. Interest is compounded when accumulated interest also earns future interest.

Present value of future sum:

Present value of future sum refers to the current value of sum of money to be received in the future. The procedure to find the present value of future sum is called **discounting**.

The discounting is done because sum to be received in the future is worth somewhat less now because of the time difference assuming positive interest rate.

The equation for finding the present value of future sum is

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

where,

PV = Present value

P = Future sum

i = rate of interest

n = number of years.

Example:

Find the present value of Rs. 1000/- to be received in 5 years using an interest rate of 8%.

$$PV = \frac{1000}{(1+0.08)^5} = 681$$

A payment of Rs. 1000 to be received in 5 years has a present value of Rs. 681 at 8% interest.

TYPES OF FARMING

On the basis of similarity in crop production and livestock rearing we have TYPES OF FARMING.

The type of farming refers to the nature and degree of product or combination of products being produced and the methods and practices used for them

I. SPECIALIZED FARMING:

When a farm is organized for the production of a single commodity and this commodity is the only source of income, the farm is said to be specialized.

The major enterprise contributes more than 50% of the total farm income.

Examples are sugarcane farm, cotton farm, poultry farm, dairy farm, wheat farm etc.

Advantages:

1. Better use of land
2. Better marketing
3. Better management
4. Improved skill and efficiency
5. Economical to maintain costly machinery
6. Less requirement of labour

Disadvantages:

1. Greater risk
2. Soil fertility cannot be maintained
3. By products cannot be fully utilized
4. Income is received once or twice in a year
5. Knowledge about enterprises becomes limited.

II. DIVERSIFIED FARMING:

When a farm is organized to produce several products (commodities), each of which is itself a direct source of income, the farm business is said to be diversified. In diversified farming, no single enterprise contributes 50% of the total farms income.

Advantages:

1. Better utilization of productive resources.
2. Reduction of risks.
3. Regular and quicker returns.
4. Proper utilization of by products.

Disadvantages:

1. Supervision will become difficult.
2. Marketing problems.
3. Not economical to maintain costly machinery.

III. MIXED FARMING:

It is the type of farming under which crop production is combined with livestock raising. At least 10 per cent of gross income must be contributed by the livestock. This contribution in any case should not exceed 49%.

Advantages:

1. Maintenance of soil fertility
2. Proper use of by products

3. Facilitates intensive cultivation
4. Higher income
5. Milch cattle provide drought animals.
6. Employment of labour.

IV. RANCHING:

The practice of grazing animals on public lands is called **ranching.** Ranch land is not used for raising of crops. Ranching is followed in Australia, America and Tibet

V. A. Dry farming: Cultivation of crops in regions with annual rainfall of less than 750 mm. Crop failure is most common due to prolonged dry spells during crop period.

B. Dry land farming : Cultivation of crops in regions with annual rainfall of more than 750mm. Moisture conservation practices are necessary for crop production.

C. Rain fed farming : Cultivation of crops in regions with an annual rain fall of more than 1150 mm.

FACTORS AFFECTING TYPES OF FARMING:

Physical factors : Climate, soils, topography.

Economic factors:

1. Marketing cost
2. Relative profitability of enterprises
3. Availability of capital
4. Availability of labour
5. Land values
6. Cycles over and under production
7. Competetion between enterprises
8. Personal likes and dislikes of farmer

SYSTEMS OF FARMING.

The system of farming refers to the organizational setup under which farm is being run. It involves questions like who is the owner of land, whether resources are used jointly or individually and who makes managerial decisions.

Systems of farming, which are based on different organisational set up, may be classified into five broad categories:

a) Capitalistic farming
b) State farming
c) Collective farming

d) Peasant farming

e) Co-operative farming

1. Capitalist or Estate farming: In what is known as capitalistic or estate or corporate farming, land is held in large areas by private capitalists, corporations or syndicates. Capital is supplied by one or a few persons or by many, in which case it runs like a joint stock company. In such farms, the unit of organization is large and the work is carried on with hired labour; latest technical know how is used and extensive use of machines are made and hence they are efficient. Examples of this type of farming are frequently found in USA, Australia, Canada and few in India too. Such types of farms have been organized in the states of Bombay, Madras and Mysore for the plantation of coffee, tea and rubber and sugarcane.

The advantages of such farming are good supervision, strong organizational set up, sufficient resources etc. Their weaknesses are that it creates socio-economic imbalances and the actual cultivator is not the owner of the farm.

2.State farming: State farming as the name indicates is managed by the government. Here land is owned by the state. The operation and management is done by government officials. The state performs the function of risk bearing and decision making, which cultivation is carried on with help of hired labour. All the labourers are hired on daily or monthly basis and they have no right in deciding the farm policy. Such farms are not very paying because of lack of incentive. There is no dearth of resources at such farms but sometimes it so happens that they are not available in time and utilized fully.

3.Collective farming: The name, collective farming implies the collective management of land where in large number of families or villagers residing in the same village pool their resources eg: land, livestock, and machinery. A general body having the highest power is formed which manages the farms. The resources do not belong to any family or farmer but to the society or collective.

Collective farming has come into much prominence and has been adopted by some countries notably by the Russia and China. The worst thing with this system is that the individual has no voice. Farming is done generally on large scale and thereby is mostly mechanized. This system is not prevalent in our country.

4.Peasant farming: This system of farming refers to the type of organization in which an individual cultivator is the owner, manager and organizer of the farm. He makes decision and plans for his farm depending upon his resources which are

generally meager in comparison to other systems of farming. The biggest advantage of this system is that the farmers himself is the owner and therefore free to take all types of decisions. A general weakness of this system is that the resources with the individual are less. Another difficulty is because of the law of inheritance. An individual holding goes on reducing as all the members in the family have equal rights in that land.

5.Cooporative farming: Co-operative farming is a voluntary organization in which small farmers and landless labourers increase their income by pooling land resources. According to planning commission, Co-operative farming necessarily implies pooling of land and joint management. The working group on co-operative farming defines a co-operative farming society as "a voluntary association of cultivators for better utilization of resources including manpower and pooled land and in which majority of the members participate in farm operation with a view to increasing agricultural production, employment and income."

A co-operative farming society makes one of the following four forms

I. Co-operative better farming
II. C-operative Joint farming
III. Co-operative tenant farming
IV. Co-operative collective farming

Co-operative better farming: These societies are based on individual ownership and individual operation. Farmers who have small holdings and limited resources join to form a society for some specific purpose eg: use of machinery, sale of product. They are organized with a view to introduce improved methods of agriculture. Each farmer pays for the services which he receives from the society. The earnings of the member from piece of land, after deducting the expenses, his profit.

Co-operative Joint farming: Under this type, the right of individual ownership is recognized and respected but the small owners pool their land for the purpose of joint cultivation. The ownership is individual but the operations are collective. The management is democratic and is elected by the members of the society. Each member working on the farm receives daily wages for his daily work and profit is distributed according to his share in land.

Co-operative tenant farming: Such societies are usually organized by landless farmers. In this system usually land belongs to the society. The land is divided into plots which are leased out for cultivation to individual members. The society arranges

for agricultural requirements eg: credit, seeds, manures, marketing of the produce etc. Each member is responsible to the society for the payments of rent on his plot. He is at liberty to dispose of his produce in such a manner as he likes.

Co-operative collective farming: Both ownership and operations under this system are collective. Members do not have any right on land and they can not take farming decisions independently but are guided by a supreme general body. It undertakes joint cultivation for which all members pool their resources. Profit is distributed according to the labour and capitals invested by the members.

System of farming		**Type of ownership**	**Types of Operation ship**
I	Co-operative farming		
a	Coop. better farming	Individual	Individual
b	Coop. joint farming	Individual	Collective
c	Coop. tenant farming	Collective	Individual
d	Coop. collective farming	Collective	Collective
II	Collective farming	Society/state	Society/State
III	Capitalistic farming	Individual	Individual
IV	State farming	State	Paid Management
V	Peasant farming	Individual	Individual

FARM PLANNING

A successful farm business is not a result of chance factor. Good weather and good prices help but a profitable and growing business is the product of good planning. With recent technological developments in agriculture, farming has become more complex business and requires careful planning for successful organisation.

A **farm plan** is a programme of total farm activity of a farmer drawn up in advance. A farm plan should show the enterprises to be taken up on the farm; the practices to be followed in their production ,use of labour, investments to be made and similar other details

Farm planning enables the farmer to achieve his objectives (Profit maximization or cost minimization) in a more organized manner. It also helps in the analysis of existing resources and their allocation for achieving higher resource use efficiency, farm income and farm family welfare. Farm planning is an approach which

introduces desirable changes in farm organization and operation and makes a farm viable unit.

TYPE OF FARM PLANS

1. Simple farm planning: It is adopted either for a part of the land or for one enterprise or to substitute one resource to another. This is very simple and easy to implement. The process of change should always begin with these simple plans.

2. Complete or whole farm planning: This is the planning for the whole farm. This planning is adopted when major changes are contemplated in the existing organization of farm business.

Characteristics of Good farm plan

1. It is should be written.
2. It should be flexible..
3. It should provide for efficient use of resources.
4. Farm plan should have balanced combination of enterprises. Such combination in turn ensures,
    a. Production of food, cash and fodder crops.
    b. Maintain soil fertility.
    c. Increase in income.
    d. Improve distribution of and use of labour, power and water requirement throughout the year.
5. Avoid excessive risks.
6. Utilize farmer's knowledge and experience and take account of his likes and dislikes.
7. Provide for efficient marketing.
8. Provision for borrowing, using and repayment of credit.
9. Provide for the use of latest technology.

FARM BUDGETING

Budgeting can be used to select the most profitable plan from among a number of alternatives and to test the profitability of any proposed change in plan. It involves testing a new plan before implementing it, to be sure that it will improve profit.

Farm budgeting is a method of estimating expected income, expenses and profit for a farm business.

Types of farm budgets

1. Enterprise budget

An enterprise is defined as a single crop or livestock commodity being produced on the farm. An enterprise budget is an estimate of all income and expenses associated with a specific enterprise and estimate of its profitability.

Enterprise budget can be developed for each actual and potential enterprise in a farm plan such as paddy enterprise, wheat enterprise or a cow enterprise. Each is developed on the basis of small common unit such as one acre or one hectare for crops or one head for livestock. This permits easier comparison of the profit for alternative and competing enterprises.

Enterprise budget can be organized and presented in three sections income, variable costs and fixed costs.

The first step in developing an enterprise is to estimate the total production and expected output price. The estimated yield should be an average yield expected under normal weather conditions given the soil type and input levels to be used. The output price should be the manager's best estimate of the average price expected during the next year or next several years.

Variable costs are estimated by knowing the quantities of inputs to be used (such as seed, fertilizer, labour, manures) and their prices.

The fixed costs in a crop enterprise budget are depreciation on machinery, equipment, implements, livestock, farm building etc., rental value of land, land revenue, interest on fixed capital.

Example: Enterprise budget for paddy production (one hectare)

I)	**INCOME**	
	48 quintals @ Rs. 600 per quintal	28,800
II)	**VARIABLE COSTS**	
1.	Human labour	9,000
	a) Owned	3,000
	b) Hired	6,000
2.	Bullock labour	300
	a) Owned	100
	b) Hired	200
3.	Tractor power	4,000
	a) Owned	1,000
	b) Hired	3,000
4.	Seeds	1,200
5.	F.Y.M.	1,800
6.	Green leaf manures	700
7.	Fertilizers	3,000
8.	Plant protection chemicals	500
9.	Irrigation charges	500
10.	Interest on working capital	1,700
	Total variable costs	22,700

III) **FIXED COSTS**

1.	Land revenue	12
2.	Depreciation	900
3.	Rent on owned land	3,500
4.	Interest on fixed capital	450
	Total fixed costs	4,862
	Total costs	27,562
	Gross margin (T.R. - T.V.C.)	6,100
	Profit (T.R.-T.C.)	1,238

2. Partial budget

It is used to calculate the expected change in profit for a proposed change in the the farm business. Partial budget is best adopted to anlysing relatively small change in the whole farm plan.

Changes in the farm plan or organization adopted to analysis by use of partial budget are of three types.

1. Enterprise substitution: This includes a complete or partial substitution of one enterprise for another. For example, substitution of sunflower for groundnut.
2. Input substitution : Example : Machinery for labour, changing livestock rations, owning a machine instead of hiring, increasing or decreasing fertilizers or chemicals.
3. Size or scale of operation: This includes changing in total size of the farm business or in the size of the single enterprise, buying or renting of additional land , expanding or decreasing an enterprise.

Partial budget format

Proposed change

……

Additional cost (Rs.)	Additional income (Rs.)
Reduced income (Rs.)	Reduced costs (Rs.)
A. Total of additional costs and reduced income _____	B. Total of additional income and reduced Costs_____

Net change in profit (B-A)

1. Additional costs

A proposed change may cause additional costs because of a new or expanded enterprise requiring the purchase of additional inputs.

2. Reduced income

Income may be reduced if the proposed change would eliminate an enterprise, reduce the size of an enterprise or cause a reduction in yield.

3. Additional income

A proposed change may cause an increase in total farm income if a new enterprise is being added, if an enterprise is being expanded or if the change will cause yield levels to increase.

4. Reduced costs

Costs may be reduced if the change results in elimination of an enterprise, or reduction in size of an enterprise or some change in technology which decreases the need for variable resources.

Partial budgeting is intermediate in scope between enterprise budgeting and whole farm planning. 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 are included and not total values. The final result is an estimate of the increase or decrease in profit.

3. Complete Budget or Whole farm budget

It is statement of expected income, expenses, and profit of the firm as a whole.

4. Cash flow budget

It is summary of cash inflows and outflows for a business over a given time period. Its primary purpose is to estimate the future borrowing needs and loan repayment capacity of the farm business.

BASIC STEPS IN FARM PLANNING AND BUDGETING

I. RESOURCE INVENTORY:

The development of whole plan is directly dependent upon an accurate inventory of available resources. The resources provide the means for production and profit. The type and quality of resources available determine the inclusion of enterprise in whole farm plan.

1) **Land:** Land resource should receive top priority when completing the resource inventory. It is one of the fixed resources. The following are some of the important items to be included in land inventory
    a) Total number of acres available
    b) Soil types (slope, texture, depth)
    c) Soil fertility levels.
    d) Water supply or potential for developing an irrigation system.
    e) Drainage problems and possible corrective measures.
    f) Existing soil conservation practices
    g) Existing and potential pest and weed problems which might affect enterprise selection and crop yields.
    h) Climatic factors including annual rainfall, growing seasons etc.
2) **Buildings:** Listing of all farm buildings along with their size, capacity and potential uses. Livestock enterprises and crop storage may be severely limited in both number and size of the buildings available.

3) **Labour**: Labour should be analyzed for both quantity and quality. Quantity can be measured in man days of labour available from the farm operator (farmer), family members and hired labour. Labour quality is more difficult to measure, but any special skills, training and experience should be noted.
4) **Machinery**: it is also a fixed resource. The number, size and capacity of the available machinery should be included in the inventory.
5) **Capital**: The farmer's own capital and estimate of amount which can be borrowed represent the capital available for developing whole farm plan.
6) **Management:** The assessment of the management resources should include not only overall management ability but also special skills, training, strengths, weaknesses of manager. Good management is reflected in higher yields and more efficient use of resources.

II. **Identifying enterprises**: Based on resource inventory, certain crop and livestock enterprises will be feasible alternatives. Care should be taken to include all possible enterprises to avoid missing enterprise with profit potential. Custom and tradition should not be allowed to restrict the list of potential enterprises.

III. **Estimation of co-efficients** : Each enterprise should be defined on small unit such one acre or hectare for crops and one head for livestock. The resource requirements per unit of each enterprise or the technical coefficients must be estimated. The technical coefficients become very important in determining the maximum size of enterprise and the final enterprise combination.

IV. **Estimating gross margins**:

A gross margin is estimated for a single unit of each enterprise. Gross margin is the difference between total income and total variable costs. Calculation of gross margin requires the farmer's best estimate of yields for each enterprise and expected prices for the output. The calculation of total variable cost requires a list of each variable input needed, the amount required and the price of each input.

V. Developing the whole farm plan:

All information necessary to organize a whole farm plan is now ready for use. The systematic procedure to whole farm planning is identifying the most limiting resource and selecting those enterprises with greatest gross margin per unit of resource.

$$\text{Returns per unit of resource} = \frac{\text{Gross Margin}}{\text{Units of resources required}}$$

Land will generally be a limiting resource and it provides a good starting point. At some point in the planning procedure, a resource other than land may become more limiting and emphasis shifts to identifying enterprises with greatest return or gross margin per unit of this resource.

LINEAR PROGRAMMING

Linear programming was developed by George B Dantzing (1947) during second world war. It has been widely used to find the optimum resource allocation and enterprise combination.

The word linear is used to describe the relationship among two or more variables which are directly proportional. For example , doubling (or tripling) the production of a product will exactly double (or triple) the profit and the required resources, then it is linear relationship.

Programming implies planning of activities in a manner that achieves some optimal result with restricted resources.

Definition of L.P.

Linear programming is defined as the optimization (Minimization or maximization) of a linear function subject to specific linear inequalities or equalities.

$$\text{Max } z \quad \sum_{j=1}^{n} c_j x_j$$

St

$$\sum_{j=1}^{n} a_{ij} \quad < b_i \qquad i=1 \text{to } m$$

$$x_j = 0$$

c_j = Net income from j^{th} activity
x_j = Level of j^{th} activity
a_{ij} = Amount of i^{th} resource required for j^{th} activity
b_i = Amount of i^{th} resource available.

Assumptions of Linear Programming

1. Linearity: It describes the relationship among two or more variables which are directly proportional.

2. Additivity: Total input required is the sum of the resources used by each activity. Total product is sum of the production from each activity.

3. Divisibility: Resources can be used in fractional amounts. Similarly, the output can be produced in fractions.

4. Finiteness of activities and resource restrictions: There is limit to the number of activities and resource constraints.

5. Non negativity: Resources and activities cannot take negative values. That means the level of activities or resources cannot be less than zero.

6. Single value expectations: Resource supplies, input-output coefficients and prices are known with certainty.

Advantages of L.P

1. Allocation problems are solved
2. Provides possible and practical solutions..
3. Improves the quality of decisions.

4. Highlights the constraints in the production.
5. Helps in optimum use of resources.
6. Provides information on marginal value products (shadow prices).

Limitations

1. Linearity
2. Considers only one objective for optimization.
3. Does not consider the effect of time and uncertainty
4. No guarantee of integer solutions
5. Single valued expectations.

Complete budgeting	**Partial budgeting**
1. It is adopted when drastic changes in the existing organization are contemplated	1. Adopted when minor changes are introduced on the farm.
2. All the available alternatives are considered	2. Considers few or only two alternatives
3. It is a method of estimating expected income, expenses and profit for the farm as a whole	3. It is used to calculate expected change in profit for a proposed minor modification

Farm budgeting	**Linear programming**
1. Method of estimating expected income, expenses and profit for the farm business	1. Optimization of linear function subject to linear inequalities or equalities.
2. Non mathematical tool	2. Mathematical programming models
3. It is a trial and error method	3. It offers a mechanical process of calculations in the selection of products
4. Computation become tedious and cumbersome.	4. Computations are easy..

RISK AND UNCERTAINTY

Farmers must make decisions on crops to be planted, seeding rates, fertilizer levels and other input levels early in the cropping season. The crop yield obtained as a result of these decisions will not be known with certainty for several months or even several years in the case of perennial crops. Changes in weather, prices and other factors between the time the decision is made and the final outcome is known can make previously good decision very bad.

Because of time lag in agricultural production and our inability to predict the future accurately, there are varying amounts of risk and uncertainty in all farm

management decisions. If everything was known with certainty, decision would be relatively easy. However, in the real world more successful manager are the ones with the ability to make the best possible decisions, and courage to make them when surrounded by risk and uncertainty.

Definition of risk and uncertainty

Risk is a situation where all possible outcomes are known for a given management decision and the probability associated with each possible outcome is also known. Risk refers to variability or outcomes which are measurable in an empirical or quantitative manner. Risk is insurable.

Uncertainty exists when one or both of two situations exist for a management decision. Either all possible outcomes are unknown, the probability of the outcomes is unknown or nether the outcomes nor the probabilities are known. Uncertainty refers to future events where the parameters of probability distribution (mean yield or price, the variance, range or dispersion and the skew and kurtosis) cannot be determined empirically. Uncertainty is not insurable.

Sources of risk and uncertainty

The most common sources of risk are.

1. Production risk: Crop and livestock yields are not with certainty before harvest or final sale weather, diseases, insects, weeds are examples of factors which can not be accurately predicted and cause yield variability.

Even if the same quantity and quality of inputs are used every year, these and other factors will cause yield variations which cannot be predicted at the time most input decision must be made. The yield variations are examples of production risk.

Input prices have tended to be less variable than output prices but still represent another source of production risk. The cost of production per unit of output depends on both costs and yield. Therefore, cost of production is highly variable as both input prices and yield vary.

2. Technological risk: Another source of production risk is new technology. Will the new technology perform as expected? Will it actually reduce costs and increase yields? These questions must be answered before adopting new technology.

3. Price or marketing risk: Variability of output prices is another source of risk. Commodity prices vary from year to year and may have substantial seasonal variation within a year. Commodity prices change for number of reasons which are beyond the control of individual farmer.

4. Financial risk: Financial risk is incurred when money is borrowed to finance the operation of farm business. There is some chance that future income will not be sufficient to repay the debt. Changes may take place in the interest rates, scale of finance, and ability of the business to generate income.

METHODS OF REDUCING RISK AND UNCERTAINTY

The various methods which can be used to reduce risk are discussed hereunder.

1. Diversification: Production of two or more commodities on the farm may reduce income variability if all prices and yields are not low or high at the same time.

2. Stable enterprises: Irrigation will provide more stable crop yields than dry land farming. Production risk can be reduced by careful selection of the enterprises with low yield variability. This is particularly important in areas of low rainfall and unstable climate.

3. Crop and livestock insurance: For phenomena, which can be insured, possible magnitude of loss is lessened through converting the chance of large loss into certain cost.

4. Flexibility: Diversification is mainly a method of preventing large losses. Flexibility is a method of preventing the sacrifice of large gains. Flexibility allows for changing plans as time passes, additional information is obtained and ability to predict the future improves.

5. Spreading sales: Instead of selling the entire crop output at one time, farmers prefer to sell part of the output at several times during the year. Spreading sales avoids selling all the crop output at the lowest price of the year but also prevents selling at the highest price.

6. Hedging: It is a technical procedure that involves trading in a commodity futures contracts through a commodity broker.

7. Contract sales: Producers of some specialty crops like gherkins, vegetables often sign a contract with a buyer or processor before planting season. A contract of this type removes the price risk at planting time.

8. Minimum support price: The government purchases the farm commodity from the farmers if the market price falls below the support price.

9. Net worth: It is the net worth of the business that provides the solvency, liquidity and much of the available credit.

AGRICULTURAL PRODUCTION ECONOMICS

BASIC TERMS AND CONCEPTS USED IN AGRICULTURAL PRODUCTION ECONOMICS AND FARM MANAGEMENT

1. FARM: It means a piece of land where crops and livestock enterprises are taken up under a common management and has specific boundaries.

2. AGRICULTURAL HOLDING: The area of the land for cultivation as a single unit held by an individual or joint family or more than one farmer on joint basis. The land may be owned, taken on lease or may be partly owned and partly rented.

3. OPERATIONAL HOLDING: It refers to the total land area held under single management for the purpose of cultivation. It excludes any land leased to another person.

4. UNITS OF ACCOUNTING: Application of inputs or measurement of output relate to technical unit, plant or an economic unit.

a) TECHNICAL UNIT: Single, convenient unit in production for which technical coefficients (input-output coefficients) are calculated. Examples are an acre, a hectare, a cow etc.

b) PLANT: Generally refers to a group of technical units such as dairy enterprise or say 15 acre farm.

c) FARM FIRM: Aggregation of resources for which costs and returns are worked out as a whole. Farm-firm is also known as economic unit. Example: a farm holding.

5. RESOURCES AND RESOURCE SERVICES:

Resources	Resource services
1. Any commodity or goods used by the firms in production	1. A services is any act or performance that one party can offer to another
2. Physical products (material) and tangible	2.Neither material nor tangible.
3. Resources get consumed or physically enter the production process so as to be transformed into products.	3.Only services are available which are transformed into products.
4. Resources being physical products can be stored.	4.Services cannot be stored(Perishable).
5. Ex: Seeds, manures, fertilizers,	5.Ex: Services of land, labour,

plant protection chemicals, herbicides, irrigation water, feeds, veterinary medicines, fuel etc., machinery, equipment, implements, livestock, farm buildings etc.,

Resources and resource services are called factors of production. They are needed to produce any commodity.

6. FIXED RESOURCES:

a) The resources whose use remains the same regardless of the level of production are called fixed resources.

b) Volume of output does not directly depend up on these resources.

c) Costs corresponding to these resources are known as fixed costs.

d) Fixed resources exist only in the short run and in the long run they are zero

Example: land, machinery, farm buildings, equipment, implement, livestock etc.,

7. VARIABLE RESOURCES:

a) The resources whose use vary with the level of production are known as variable resources.

b) Volume of output directly depends on these resources.

c) Costs corresponding to these resources are known as variable costs.

d) Variable resources exist both in the short run and in the long run.

Seeds, Fertilizers, Plant protection chemicals, FYM, feeds, medicines etc., are examples of variable resources.

8.FLOW AND STOCK RESOURCES:

Flow Resources: There are some resources which should be used as and when they are available. They cannot be stored or stocked for a future use. Services are forthcoming like a flow. Examples are labour, Sunshine, land, farm buildings, machinery, equipment etc.

Stock Resources: The resources which are not used in one period of production can be stored for a later period. Examples are seeds, fertilizers, feeds, manures, plant protection chemicals etc.

Some factors of production are both flow and stock services. Whether a service should be defined as flow or stock depends on the length of the time period under consideration.

Examples are land, machinery, buildings etc.

A building lasts for 50 years provides a flow of services in each of the individual years, still it provides a stock of services for 50 years period. Similarly a tractor gives flow of services for each year, but a stock service over 10 years.

9. PRODUCTION: It is a process whereby some goods and services called inputs are transformed into other goods called output is known as production.

(Or)

Production is a process of transformation of certain resources (inputs) into products.

10. PRODUCT: It is the result of the use of resources. Product is any good or service that comes out of the production process.

11. TRANSFORMATION PERIOD (OR) PRODUCTION PERIOD:

The time required for a resource to be completely transformed into a product is referred to as transformation period.

The production period varies with the type of resource. Some resources are transformed into products in short time period (seeds, feed, fuel, fertilizers, manures, plant protection chemicals etc.,). Others over a long period of time (machines, buildings etc) and still others are never completely transformed (land). The variations in production period give rise to complexities in decision making.

12. CHOICE INDICATOR:

It is a yardstick, or an index or a criterion indicating which of two or more alternatives is optimum or will maximize a given end.

The choice indicator as a yardstick by which selection between alternatives is made, indicates the relative value which is attached to one as compared to another alternative.

Choice indicators can be applied to problems in physical production as well as to those of profit maximization and consumer welfare. Choice indicators in economics are almost always given as ratios: examples are substitution ratios and price ratios.

13. <u>SHORT RUN AND LONG RUN</u>: These are time concepts but they are not defined as fixed periods of calendar time.

The short run is that period of time during which one or more of the production inputs is fixed in amount and cannot be changed.

The level of production can be varied to a little extent by intensive use of fixed resources or by using more amounts of variable resources. During the short period, demand and supply change a little but not much.

For example, at the beginning of the planting season, it may be too late to increase or decrease the amount of crop land owned or rented. The current crop production cycle would be a short run period as land is fixed in amount.

The long run is defined as that period of time during which the quantity of all necessary productive inputs can be changed.

The level of production can be varied to a greater extent by varying all the factors of production. Demand and supply conditions have plenty of time to adjust themselves.

In the long run, a business can expand by acquiring additional inputs or go out of existence by selling all inputs.

Depending on which input(s) are fixed, the short run may be anywhere from several days to several years. One year or one crop or livestock production cycle are common short run periods in agriculture.

The distinction between fixed and variable resources holds true only in the short run. In the long run, all resources are variable .

14. <u>COST OF CULTIVATION</u>: It refers to the cost of various inputs and input services used for raising a particular crop. It includes all the operations from land preparation to threshing, cleaning and taking the product from the field to home. Cost of cultivation always refers to unit area (acre or hectare).

15. <u>COST OF PRODUCTION</u>: It refers to the cost of various inputs and input services used to produce a unit quantity of output of a commodity.

16. <u>ECONOMY</u>: It is a system which provides people with means to work and earn a living. Economy consists of all sources of employment and production such as firms, factories, workshops, mines etc.

17. <u>ECONOMIC SYSTEM</u>: It is an institutional framework within which society carries the economic activities.

18. EFFICIENCY: it means absence of waste or using the economy's resources as effectively as possible to satisfy people's needs and desires.

19. TECHNIOCAL EFFICIENCY: It refers to the amount of output with given amounts of factors of production. In other words, technical efficiency is the ratio of output to input (Average physical product).

Technical efficiency = Y/X, Where Y= Total output and X= Quantity of input

20. ECONOMIC EFFICIENCY: It is a ratio of value of output to value of input.

Economic efficiency = Y.Py / X.Px

21. OPTIMUM: It is the ideal condition in which the costs are minimum and profits are maximum.

22. MONOPERIOD RESOURCES: The resources which can be used in a single production period are called mono period resources. Seeds, feeds, fuel, fertilizers, manures, plant protection chemicals are some of the examples of mono period resources.

23. POLYPERIOD RESOURCES: The resources which provide their services for several years in production are known as poly period resources. Examples are land, livestock, machinery, equipment, buildings etc.

24. ENTERPRISE: It is defined as a single crop or livestock commodity being produced on a farm.

25. FARM ENTERPRENEUR: He is the person who thinks of, organizes and operates the business and is responsible for the losses and gains from the business. He is a pioneer in organizing and developing the farm firm.

26. FARM MANAGER: He is a person who manages or supervises the business according to instructions of the entrepreneur. He is hired to manage the business. He is not generally responsible for any gain or loss to the business.

27. PRODUCTION FUNCTION (PF):

It is the systematic way of showing the relationship between different amounts of inputs that can be used to produce a product and the corresponding output of that product.

Definition : Production function is a technical and mathematical relationship describing the manner and the extent to which a particular product depends upon the quantities of inputs or input services, used at a given level of technology and in a given period of time.

In short, the relationship between input and output is termed as production function.

Types of Production Functions:

1. Continuous Production Function: This is obtained for those inputs which can be split up in to smaller units. All those inputs which are measurable give raise to continuous production function.

Example: Fertilizers, Seeds, Plant protection chemicals, Manures, Feeds etc

2. Discontinuous or discrete Production Function: Such a function is obtained for resources or work units which are used or done in whole numbers. In other words, production function is discrete, where inputs cannot be broken in to smaller units. Alternately stated, discrete production is obtained for those inputs which are counted.

Example: Ploughing, Weeding, Irrigation etc.,

3. Short Run Production Function (SRPF): Production Function in which some inputs or resources are fixed.

$$Y = f(X_1 / X_2, X_2, \ldots\ldots\ldots\ldots, X_n)$$

Eg: Law of Diminishing returns or Law of variable proportions

4. Long Run Production Function (LRPF): Production function which permits variation in all factors of production.

$$Y = f((X_1, X_2, X_3, \ldots\ldots\ldots\ldots, X_n)$$

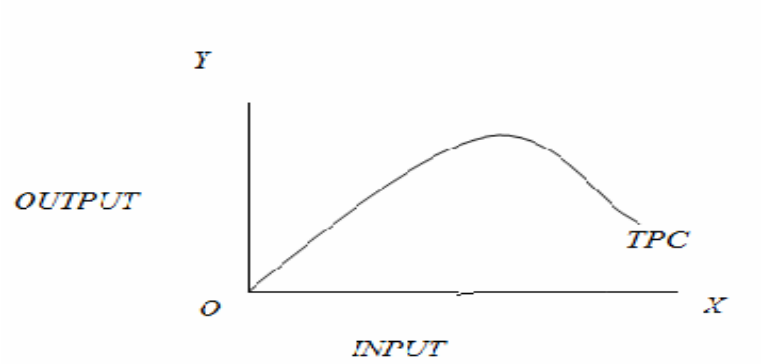
Eg: Returns to scale.

The production function can be expressed in three ways:

1. **Tabular form**: Production function can be expressed in the form of a table, where one column represents input, while another indicates the corresponding total output of the product. The two columns constitute production function.

Input (x)	Output (y)
0	2
10	5
20	11
30	18
40	25

2. **Graphical Form**: The production function can also be illustrated in the form of a graph; where horizontal axis (X axis) represents input and the vertical axis (Y axis) represents the output.



3. **Algebraic Form**: Algebraically production function can be expressed as

$Y = f(X)$

Where , Y represents dependent variable, output (yield of crop, livestock enterprise) and X represents independent variable, input (seeds, fertilizers, manure etc),

f = denotes function of

When more number of inputs is involved in the production of a product, the equation is represented as

$Y=f(X_1, X_2, X_3, X_4 \ldots\ldots\ldots X_n)$

In case of single variable production function, only one variable is allowed to vary, keeping others constant, can be expressed as

$Y=f(X_1 \mid X_2, X_3 \ldots\ldots\ldots X_n)$

The vertical bar is used for separating the variable input from the fixed input. The equation denotes that the output Y depends upon the variable input X_1, with all other inputs held constant.

If more than one variable input is varied and few others are held constant, the relationship can be expressed as

$Y=f(X_1, X_2 \mid X_3, X_4 \ldots\ldots\ldots X_n)$

Production function can also be expressed as

$Y=a+bX$ _____ Linear production function

Where Y is dependent variable,

a is constant,

b is coefficient,

X is independent variable

The constant a represents the amount of product obtained from the fixed factor if none of the variable input is applied, while b is the amount of output produced for each unit of X (input) applied.

$Y = aX^b$

Is an exponential equation and is known as Cobb-Douglas production function.

$Y = a+bX \pm cX^2$ is quadratic equation

Production function depends on the following factors:

1. Quantities of inputs used
2. Technical knowledge of the producer.
3. Possible processes in production
4. Size of the firm
5. Nature of firm's organization
6. Relative prices of factors of production.

AGRICULTURAL PRODUCTION ECONOMICS

Meaning, Nature and Scope

Agricultural production economics is a field of specialization within the subject of agric ultural economics. It is concerned with the choice of production patterns and resource use in order to maximize the objective function of farmers, their families, the society or the nation within a framework of limited resources.

Production economics is concerned with two broad categories of decisions in the production process.

1. How to organize resources in order to maximize the production of a single commodity? i.e, Choice making among various alternative ways of using resources.
2. What combination of different commodities to produce?

Goals of Production Economics

1. To provide guidance to individual farmers in using their resources most efficiently.
2. To facilitate the most efficient use of resources from the stand point of economy

Definition: ***Agricultural Production Economics is an applied field of science wherein the principles of choice are applied to the use of capital, labour, land and management resources in the farming industry.***

Subject matter of Agricultural Production Economics

With a view to optimizing the use of farm resources on an individual farm level and to rationalize the use of resources from a national angle, production economics involves analysis of relationships and principles of rational decisions.

Production Economics is concerned with productivity i.e use and incomes from productive inputs (land, labour, capital and management). As a study of resource productivity, it deals with

a) Resource use efficiency
b) Resource combination
c) Resource allocation
d) Resource management
e) Resource administration

The subject matter of Production Economics includes such topics as methods or techniques of production, combination of enterprises, size of the farm, return to scale, leasing, production possibilities, farming efficiency, soil conservation, use of credit and capital, risks and uncertainty which effect decision making.

Any agricultural problem that falls under the scope of resource allocation and marginal productivity analysis is the subject matter of the production economics. The production economist is therefore, concerned with any phenomena which have a bearing on economic efficiency in the use of agricultural resources.

Objectives

The main objectives of Agricultural production economics are:

1. To determine and define the conditions which provide for optimum use of resources.
2. To determine the extent to which the existing use of resources deviates from the optimum use.
3. To analyze the factors or forces which are responsible for the existing production pattern and resource use and

4. To explain means and methods for changing existing use of resources to the optimum level.

Basic production problems

The producer or manager is faced with five basic production problems on which they have to make decisions.

1. WHAT TO PRODUCE?

This problem involves selecting the combination of crops and livestock enterprises to be produced. Should the business produce only crops, only livestock or some combination? Which crop or rotations? Which livestock? The farmer must select from among many alternatives that combination which will maximize profits.

2. HOW TO PRODUCE?

Many agricultural products can be produced in a number of ways. Crops can be produced with more capital and less labour (capital intensive technology) or more labour and less capital (labour intensive technology). A manager must select the appropriate combination of inputs which will minimize the cost of producing a given quantity of some commodity.

3. HOW MUCH TO PRODUCE?

The level of production and profit will be determined by the input levels selected. A manager is faced with the problems of how much fertilizer and irrigation water to use, seed rates, feeding levels, labour and machinery use etc.

4. WHEN TO BUY AND SELL?

The seasonality of supply conditions in factor and product market results in variations in the prices. The manager must consider these things in determining when to sell or buy.

5. WHERE TO BUY AND SELL?

Farmers generally purchase a number of inputs for a production. Attempt is always to purchase at the least cost. The producer must decide whether to sell in the village market or in the regulated market or other alternative market.

Laws of Returns

Production is the result of cooperative working of various factors of production viz ., land , labour, capital and management. The laws of returns operate on account of variability in the proportion in which the various factors can be combined for the purpose of production.

In the production of a commodity where one input is varied, keeping all inputs fixed, the nature of relationship between single variable input and output can be either of the one or a combination of the following:

1. Law of increasing returns
2. Law of constant returns
3. Law of decreasing returns

Law of increasing returns (Increasing marginal productivity)

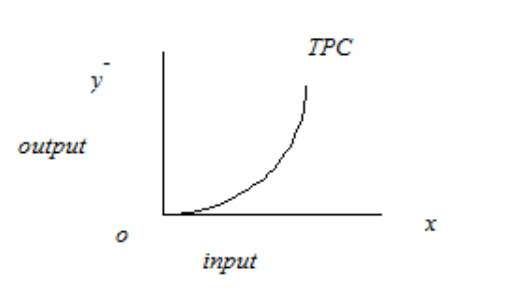
Each successive unit of variable input when applied to the fixed factor adds more and more to the total product than the previous unit .

The marginal physical product is increasing and hence known as law of increasing returns.

Increasing returns means lower costs per unit of output. Thus the law of increasing returns signifies that cost per unit of additional product falls as more and more output is produced. Hence law of increasing returns also called law of decreasing costs.

Input(X)	Output(Y)	? X	? Y	? Y/?X=MPP
1	2	1	2	2/1=2
2	6	1	4	4/1=4
3	12	1	6	6/1=6
4	20	1	8	8/1=8
5	30	1	10	10/1=10

As shown in the above table, the first unit of variable input adds 2 units, while the second add 4 units to the total output, the third add 6 units and so on



When production function is graphed with output on vertical axis and input on horizontal axis, the resulting curve is convex to the origin.

Algebraically increasing returns is expressed as

$?_1Y/?_1X < ?_2Y/?_2X < \ldots\ldots\ldots\ldots < ?_nY/?_nX$

Law of constant returns (constant marginal productivity)

Each additional unit of variable input when applied to the fixed factors produces an equal amount of additional product. The amount of product (TPP) increases by the same magnitude for each additional unit of input.

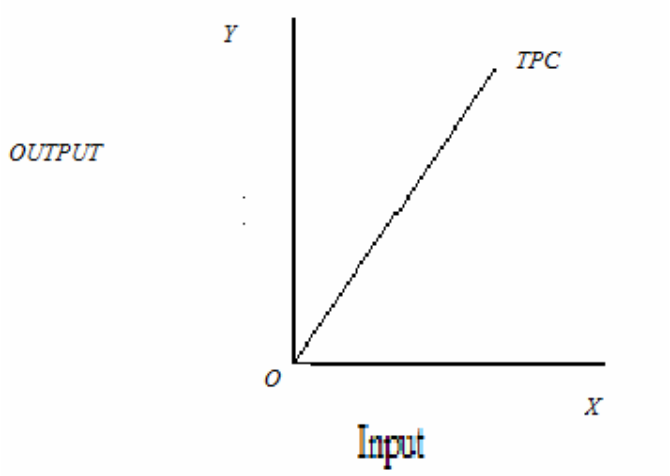
The marginal physical product remains the same for each additional unit of input and hence it is called law of constant marginal productivity.

Regardless of the scale of production, the cost of additional unit of product remains the same and hence it is also called law of constant costs.

Linear production function or constant returns is not a common relationship in agriculture.

Input(X)	Output(Y)	? X	? Y	? Y/?X=MPP
1	10	1	10	10/1=10
2	20	1	10	10/1=10
3	30	1	10	10/1=10
4	40	1	10	10/1=10
5	50	1	10	10/1=10

As shown in the table, each unit of input adds 10 units. The shape of the total product curve is linear. Linear production indicates constant returns.



Algebraically constant returns is expressed as

$? {}_1Y/? {}_1X = ? {}_2Y/? {}_2X = \ldots\ldots\ldots\ldots = ? {}_nY/? {}_nX$

Law of Decreasing returns (Decreasing marginal productivity)

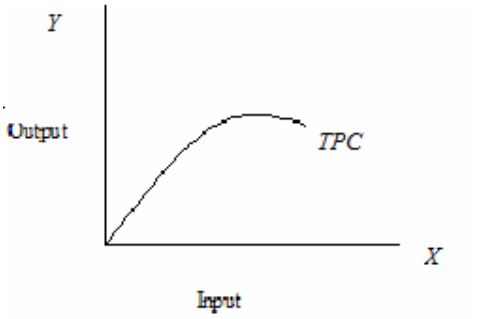
Each additional unit of variable input when applied to the fixed factors adds less and less to the total product than the previous unit.

The marginal physical product is declining , hence the name law of decreasing returns.

Input X	Input Y	? X	? Y	? Y/?X=MPP
1	25	1	25	25/1=25
2	45	1	20	20/1=20
3	60	1	15	15/1=15
4	70	1	10	10/1=10
5	75	1	5	5/1=5

As shown in the table, the first unit of input adds 25 units, the second adds 20 units and the third adds 15 units and so on.

The production function which exhibits diminishing returns is concave to the origin. Law of diminishing returns is very common in agriculture.



The cost of each additional unit of output increases as we produce more and more output and hence it is called Law of increasing costs.

Algebraically , it can be expressed as

$?_1Y/?_1X > ?_2Y/?_2X > \ldots\ldots\ldots\ldots > ?_nY/?_nX$

BASIC PRODUCTION RELATIONSHIPS

Production of farm commodities involves numerous relationships between resources and products. Some of these relationships are simple, others are complex. Knowledge of these relationships is essential as they provide the tools by means of which the problems of production or resource use can be analyzed.

Major production relationships are:

1. Factor-Product relationship
2. Factor-Factor relationship
3. Product-Product relationship

Factor-Product Relationship

1. It deals with the production efficiency of resources.
2. The rate at which the factors are transformed in to products is the study of this relationship.
3. Optimization of production is the goal of this relationship.
4. This relationship is known as input-output relationship by farm management specialists and fertilizer responsive curve by agronomists.
5. Factor-Product relationship guides the producer in making the decision 'how much to produce?'.

6. This relationship helps the producer in the determination of optimum input to use and optimum output to produce.
7. Price ratio is the choice indicator.
8. This relationship is explained by the law of diminishing returns.
9. Algebraically, this relationship can be expressed as

$Y = f(X_1 / X_2, X_3 \ldots\ldots\ldots\ldots X_n)$

Law of Diminishing Returns

The factor - product relationship or the amount of a resource that should be used and consequently the amount of output that should be produced is directly related to the operation of law of diminishing returns.

This law explains how the amount of product obtained changes as the amount of one of the resources is varied while the amount of other resources is fixed.

It is also known as law of variable proportions or principle of added costs and added returns.

Definitions:

- An increase in capital and labour applied in the cultivation of land causes in general less than proportionate increase in the amount of produce raised, unless it happens to coincide with the improvements in the arts of agriculture (Marshall)
- If the quantity of one of productive service is increased by equal increments, with the quantity of other resource services held constant, the increments to total product may increase at first but will decrease after certain point (Heady)

Limitations:

The law of diminishing returns fails to operate under certain situations. They are called limitations of the law.

1. Improved methods of cultivation
2. New soils and
3. Insufficient capital.

Why the law of diminishing returns operates in agriculture:

The law of diminishing returns is applicable not only to agriculture but also manufacturing industries. This law is as universal as the law of life itself. If the industry is expanded too much and becomes unwidely, supervision will become difficult and the costs will go up. The law of diminishing returns, therefore set in. The only difference is that in agriculture it sets in earlier and in industry much later. There are several reasons for the operation of law of diminishing returns in agriculture. The reasons are:

1. Excessive dependence on weather.
2. Limited scope for mechanization.
3. Limited scope for division of labour.
4. Agriculture uses larger proportion of land resource.
5. Soil gets exhausted due to continuous cultivation.
6. Cultivation is extended to inferior lands.

Concepts of production:

1. *Total product (TP)*: Amount of product which results from different quantities of variable input. Total product indicates the technical efficiency of fixed resources.

2. *Average Product (AP):* It is the ratio of total product to the quantity of input used in producing that quantity of product.

AP= Y/X where Y is total product and X is total input.

Average product indicates the technical efficiency of variable input.

3. *Marginal product (MP):* Additional quantity of output resulting from an additional unit of

input.

MP= Change in total product / Change in input level (?Y/? X)

4. *Total Physical Product (TPP):* Total product expressed in terms of physical units like kgs, quintals, tonnes is termed as total physical product.

Similarly if AP and MP are expressed in terms of physical units, they are called Average Physical Product (APP) and Marginal Physical Product (MPP).

5. *Total Value Product (TVP):* Expression of TPP in terms of monetary value, it is called Total Value Product.

TVP = TPP ? P_y or Y? P_y

6. *Average Value Product (AVP):* The expression of Average Physical Product in money value.

$$AVP = APP \times P_y$$

7. *Marginal Value Product (MVP):* When MPP is expressed in terms of money value, it is called Marginal Value Product.

$$MVP = MPP \times P_y \text{ or } (\Delta Y/\Delta X) \times P_y = \Delta Y \cdot P_y / \Delta X$$

Relationship between Total Product (TP) and Marginal Product (MP):

- When Total Product is increasing, the Marginal Product is positive.
- When Total Product remains constant, the Marginal Product is zero.
- When Total Product decreases, Marginal Product is negative.
- As long as Marginal Product increases, the Total Product increases at increases at increasing rate.
- When the Marginal Product remains constant, the Total Product increases at constant rate.
- When the Marginal Product declines, the Total Product increases at decreasing rate.
- When Marginal Product is zero, the Total Product is maximum.
- When marginal product is less than zero (negative), total physical product declines at increasing rate.

Relationship between Marginal and Average Product

- When Marginal Product is more than Average Product, Average Product increases.
- When Marginal Product is equal with the Average Product, Average Product is Maximum.
- When Marginal Product is less than Average Product, Average Product decreases.

Relationship between TP, AP and MP

Input (X)	Total Product (Y)	Average Product AP = Y/ X	Marginal Product (? Y / ? X)	Remarks
0	0	-	-	
1	2	2	2	Increasing
2	5	2.5	3	returns
3	9	3.0	4	
4	14	3.5	5	Constant
5	19	3.8	5	returns
6	23	3.83	4	
7	26	3.71	3	
8	28	3.5	2	Decreasing
9	29	3.22	1	returns
10	29	2.9	0	
11	28	2.54	-1	
12	26	2.16	-2	Negative returns

Elasticity of Production (E_p):

It is a measure of responsiveness of output to changes in input. The elasticity of production refers to the proportionate change in output as compared to proportionate change in input.

E_p = Percentage change in output/Percentage change in input.

E_p = ((change in output / initial output)*100) / ((change in input / initial input)*100)

i.e., ((? Y/Y)*100)/((? X/X)*100)

= (? Y/Y) / (? X/X) = (? Y/Y)*(X/? X) = (? Y/? X) * (X/Y)

By rearranging we have,

(? Y/?X) * (X/Y) = (?Y/? X)/(Y/X) = MPP/APP

The elasticity of production is the ratio of Marginal Physical Product to Average Physical Product.

E_p = 1 ,Constant Returns. E_p is one at MPP = APP (At the end of I stage)

E_p > 1 , Increasing Returns (I Stage of Production)

E_p < 1 , Diminishing returns (II Stage of Production)

$E_p = 0$, When MPP is zero or TPP is Maximum (At the end of II stage)

$E_p < 0$, Negative Returns (III Stage of Production)

Three Regions of Production Function

The production function showing total, average and marginal product can be divided into three regions, stages or zones in such a manner that one can locate the zone of production function in which the production decisions are rational.

The three sages are shown in the figure.

First Stage or I Region or Zone 1:

- The first stage of production starts from the origin i.e., zero input level.
- In this zone, Marginal Physical Product is more than Average Physical Product and hence Average Physical Product increases through out this zone.
- Marginal Physical Product (MPP) is increasing up to the point of inflection and then declines.
- Since the marginal Physical Product increases up to the point of inflection, the Total Physical Product (TPP) increases at increasing rate.
- After the point of inflection, the Total Physical Product increases at decreasing rate.
- Elasticity of production is greater than unity up to maximum Average Physical Product (APP).
- Elasticity of production is one at the end of the zone (MPP = APP).
- In this zone fixed resources are in abundant quantity relative to variable resources.
- The technical efficiency of variable resource is increasing throughout this zone as indicated by Average Physical Product.
- The technical efficiency of fixed resource is also increasing as reflected by the increasing Total Physical Product.
- Marginal Value Product is more than Marginal Factor Cost (MVP >MFC)
- Marginal revenue is more than marginal cost (MR > MC)
- This is irrational or sub-optimal zone of production.
- This zone ends at the point where MPP=APP or where APP is Maximum.

Second Stage or II Region or Zone II:

1. The second zone starts from where the technical efficiency of variable resource is maximum i.e., APP is Maximum (MPP=APP)
2. In this zone Marginal Physical Product is less than Average Physical Product. Therefore, the APP decreases throughout this zone.
3. Marginal Physical Product is decreasing throughout this zone.
4. As the MPP declines, the Total Physical Product increases but at decreasing rate.
5. Elasticity of production is less than one between maximum APP and maximum TPP.
6. Elasticity of production is zero at the end of this zone.
7. In this zone variable resource is more relative to fixed factors.
8. The technical efficiency of variable resource is declining as indicated by declining APP.
9. The technical efficiency of fixed resource is increasing as reflected by increasing TPP.
10. Marginal Value Product is equal to Marginal Factor Cost (MVP=MFC).
11. Marginal Revenue is equal to Marginal Cost (MR= MC)
12. This is rational zone of production in which the producer should operate to attain his objective of profit maximization.
13. This zone ends at the point where Total Physical Product is maximum or Marginal Physical Product is zero.

Third Stage or III Region or Zone III:

- This zone starts from where the technical efficiency of fixed resource is maximum (TPP is Max).
- Average Physical Product is declining but remains positive.
- Marginal Physical Product becomes negative.
- The Total Physical Product declines at faster rate since MPP is negative.
- Elasticity of production is less than zero ($E_p < 0$)
- In this zone variable resource is in excess capacity.
- The technical efficiency of variable resource is decreasing as reflected by declining APP.
- The technical efficiency of fixed resource is also decreasing as indicated by declining TPP.

- ❖ Marginal Value Product is less than Marginal Factor Cost (MVP < MFC)
- ❖ Marginal Revenue is less than Marginal Cost (MR < MC)
- ❖ This zone is irrational or supra-optimal zone.
- ❖ Producer should never operate in this zone even if the resources are available at free of cost.

Three Regions of Production-Economic decisions

Stage I: It is called irrational zone of production. Any level of resource use falling in this region is uneconomical. The technical efficiency of variable resource is increasing throughout the zone (APP is increasing). Therefore, it is not reasonable to stop using an input when its efficiency is increasing.

In this zone, more products can be obtained from the same resource by reorganizing the combination of fixed and variable inputs. For this reason, it is called irrational zone of production.

Stage II: It is rational zone of production. Within the boundaries of this region is the area of economic relevance. Optimum point must be somewhere in this rational zone. It can, however, be located only when input and output prices are known.

Stage III: It is also an area of irrational production. TPP is decreasing at increasing rate and MPP is negative. Since the additional quantities of resource reduces the total output, it is not profitable zone even if the additional quantities of resources are available at free of cost. In case if a farmer operates in this zone, he will incur double loss. i.e.,

1. Reduced Production
2. Unnecessary additional Cost of inputs.

Factor-Factor Relationship

1. This relationship deals with the resource combination and resource substitution.
2. Cost minimization is the goal of factor -factor relationship.
3. Under factor-factor relationship, output is kept constant, input is varied in quantity.
4. This relationship guides the producer in deciding 'How to produce'.
5. This relationship is explained by the principle of factor substitution or principle of substitution between inputs.

6. Factor-Factor relationship is concerned with the determination of least cost combination of resources.
7. The choice indicators are substitution ratio and price ratio.
8. Algebraically, it is expressed as

$$Y = f(X_1\ X_2 / X_3\ X_4 \ldots\ X_n)$$

In the production, inputs are substitutable. Capital can be substituted for labour and vice versa, grain can be substituted for fodder and vice versa. The producer has to choose that input or inputs, practice or practices which produce a given output with minimum cost. The producer aims at cost minimization i.e., choice of inputs and their combinations.

Isoquants:

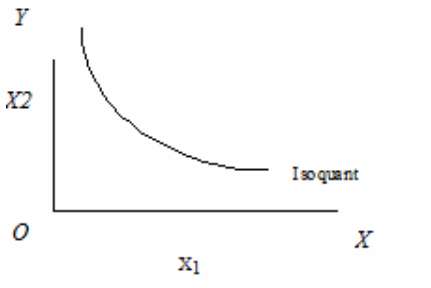
The relationship between two factors and output can not be presented with two dimensional graph. This involves three variables and can be presented in three dimensional diagram giving a production surface.

An isoquant is a convenient method for compressing three dimensional picture of production into two dimensions.

Definition *:*

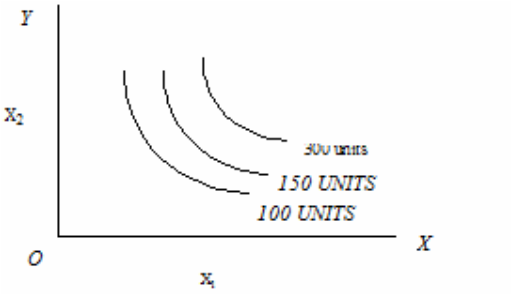
An isoquant represents all possible combinations of two resources (X_1 and X_2) physically capable of producing the same quantity of output.

Isoquants are also known as isoproduct curves or equal product curves or product indifference curves.



Isoquant Map or Iso product Contour

If number of isoquants are drawn on one graph, it is known as isoquant map. Isoquant map indicates the shape of production surface which in turn indicates the output response to the inputs.



Characteristics of Isoquants

1. Slope downwards from left to right or negatively sloped.
2. Convex to the origin.
3. Nonintersecting
4. Isoquants lying above and to the right of another represents higher level of output.
5. The slope of isoquant denotes the marginal rate of technical substitution (MRTS).

Marginal Rate of Technical Substitution (MRTS)

It refers to the amount by which one resource is reduced as another resource is increased by one unit.

Or

The rate of exchange between some units of X_1 and X_2 which are equally preferred.

$$MRTS_{X1X2} = ? X_2 / ? X_1$$

$$MRTS_{X2X1} = ? X_1 / ? X_2$$

$$\text{Marginal Rate of Technical Substitution} = \frac{\text{Number of units of replaced resource}}{\text{Number of units of added resource}}$$

The slope of Isoquant indicates MRTS.

Substitutes: A range of input combinations which will produce a given level of output. When one factor is reduced in quantity, a second factor must always be increased MRTS is always less than zero.

Perfect Substitutes: When two resources are completely interchangeable, they are called perfect substitutes.

The isoquants for perfect substitutes is negatively sloped straight lines.

The MRTS is constant.

Ex: Family labour and hired labour, Farm produced and purchased seed etc,

Complements: Two resources which are used together are called complements.

In the case of complements reduction in one factor can not be replaced by an increase in another factor.

MRTS is zero .

Perfect Complements: Two resources which are used together in fixed proportion are called perfect complements. It means that only one exact combination of inputs will produce a particular level of output.

The isoquant in this case is of a right angle.

Ex: Tractor and driver, Pair of bullocks and labourer

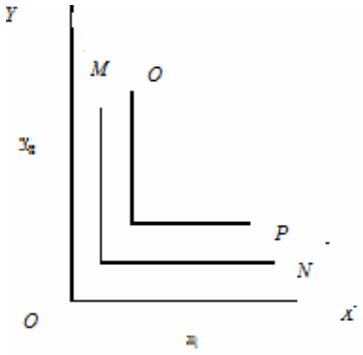
Types of factor substitution

The shape of isoquant and production surface will depend up on the manner in which the variable inputs are combined to produce a particular level of output. There can be three such categories of input combinations. They are:

1. ***Fixed Proportion combination of inputs***

To produce a given level of output, inputs are combined together in fixed proportion. Isoquants are 'L' shaped.

It is difficult to find examples of inputs which combine only in fixed proportions in agriculture. An approximation to this situation is provided by tractor and driver combination. To operate another tractor, normally we need another driver.



2. ***Constant rate of Substitution:***

For each one unit gain in one factor, a constant quantity of another factor must be sacrificed.

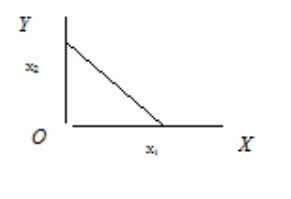
When factors substitute at constant rate, isoquants are linear, negatively sloped.

X1	X2	? X_1	? X_2	$MRTS_{X1X2}$ = ? X_2/? X_1
0	50	--	--	--
5	40	5	10	10/5=2
10	30	5	10	10/5=2
15	20	5	10	10/5=2
20	10	5	10	10/5=2
25	0	5	10	10/5=2

The above table shows that the six combinations of resources X_2 and X_2 can be used in producing a given level of output. As X_1 input is increased from 0 to 5 units ,10 units of X2 are replaced. Similarly addition of another 5 units of X_1 replaces another 10 units. The MRS of X_1 for X_2 is 2. That means if we want to obtain one unit of X_1, we have to forego 2 units of X_2.

Ex:, family labour and hired labour,

When inputs substitute at constant rate, it is economical to use only one resource, and which one to use depends up on relative prices.



Algebraically, constant rate of factor substitution is expressed as

? $_1X_2$/? $_1X_1$ = ? $_2X_2$/? $_2X_1$ = ……. = ? $_nX_2$/? $_nX_1$

3. ***Decreasing Rate of substitution:***

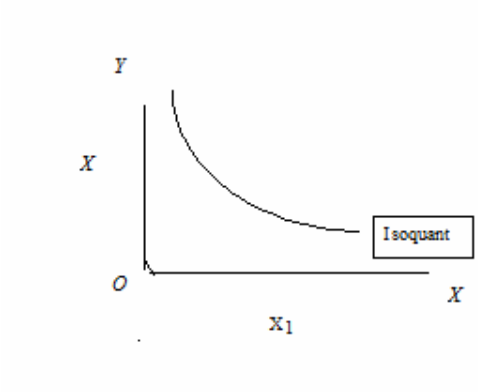
Every subsequent increase in the use of one factor replaces less and less of other factor. In other words, each one unit increase in one factor requires smaller and smaller sacrifice in another factor.

Ex: Capital and labour, concentrates and green fodder, organic and inorganic fertilizers etc.

X1	X2	? X_1	? X_2	$MRTS_{X1X2}$ = ? X_2/? X_1
1	18	--	--	--
2	13	1	5	5/1=5
3	9	1	4	4/1=4
4	6	1	3	3/1=3
5	4	1	2	2/1=2

The MRS of X1 for X2 becomes smaller and smaller as X1 replaces X2.

Isoquants are convex to the origin when inputs substitute at decreasing rate.



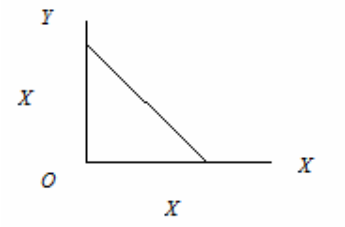
Algebraically, decreasing rate of substitution is expressed as

? $_1X_2$/? $_1X_1$ > ? $_2X_2$/? $_2X_1$ > ……. > ? $_nX_2$/? $_nX_1$

Decreasing rate of factor substitution is more common in agricultural production.

Isocost Line (price line, budget line, iso outlay line, factor cost line)

Isocost line defines all possible combinations of two resources (X_1 and X_2) which can be purchased with a given outlay of funds.



Characteristics of Isocost line:

1. As the total outlay increases, the isocost line moves farther away from the origin.

2. Isocost line is a straight line because input prices do not change with the quantity purchased.
3. The slope of isocost line indicates the ratio of factor prices.

Least Cost Combination of inputs

There are innumerable possible combinations of factors which can be used to produce a particular level of output. The problem is to find out a combination of inputs which should cost the least, a cost minimization problem. There are three methods to find out the least cost combination of inputs. They are:

1. ***Simple Arithmetical calculations:***

One possible way to determine the least cost combination is to compute the cost of all possible combinations of inputs and then select one combination with minimum cost. This method is suitable where only a few combinations produce a particular level of output.

X1	X2	X1@Rs.3	X2@Rs.2	Total cost
10	3	30	6	36
7	4	21	8	29
5	6	15	12	27
3	8	9	16	25
2	12	6	24	30

The above table shows five combinations of inputs which can produce a given level of output. The price per unit of X_1 is Rs.3/- and of X_2 is Rs.2/-. The total cost of each combination of inputs is computed.Out of five combination, 3 units of X_1 and 8 units of X_2 is the least cost combination of inputs i.e., Rs.25/-

2. ***Algebraic method:***

a) Compute Marginal Rate of technical substitution

MRS = Number of units of replaced resource / Number of units of added resource

$MRS_{X1X2} = ?X_2/?X_1$

$MRS_{X2X1} = ?X_1/?X_2$

b) Compute Price Ratio (PR)

PR=Price per unit of added resource/Price per unit of replaced resource

$PR=PX_1/PX_2$ if $MRSX_1X_2$

Or

$PR= PX_2/ PX_1$ if $MRSX_2X_1$

c) Workout least cost combination by equating MRS and PR

i.e., $?X_2/?X_1 = P_{X1}/P_{X2}$ MRS_{X1X2}

$?X_1/?X_2 = PX_2/PX_1$ $MRSX_2X_1$

The same can be expressed as

$?X_2 . PX_2 = PX_1 . ?X_1$

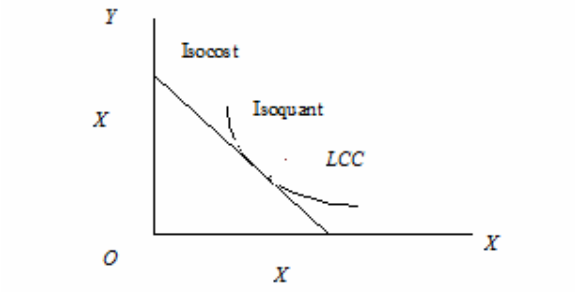
Or

$?X_1 . PX_1 = ?X_2 . PX_2$

The least cost combination is obtained when Marginal Rate of substitution is equal to Price Ratio.

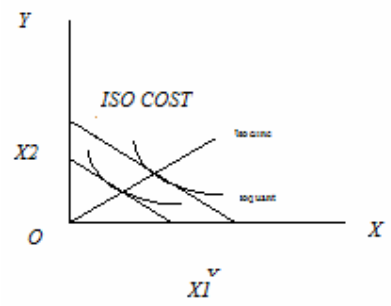
3. ***Graphical Method:***

Since the slope of isoquant indicates MRTS and the slope of isocost line indicates factor price ratio, minimum cost for given output will be indicated by the tangency of these isoclines. For this purpose, isocost line and isoquant are drawn on the same graph for different levels of production. The least cost combination will be at the point where isocost line is tangent to the isoquant i.e., slope of isoquant=slope of isocost line i.e., MRS=PR



Iso-cline

There can be number of possible output levels as shown in the figure and the least cost combination can be found out for these various output levels. A line or curve connecting the least cost combination of inputs for all output levels is called isocline.

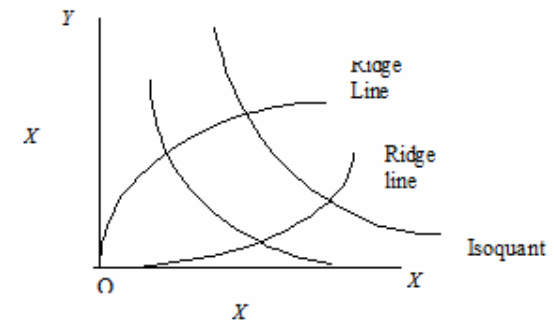


The isocline passes through all the isoquants at points where they have the same slope. Isoclines can be drawn at different sets of price ratio. All isoclines of course converge at the point of maximum output. Though all the points on isocline represent least cost combination, only one point represents the maximum profit output.

Expansion Path : Of many isoclines, the isocline which is considered to be the most appropriate over a production period is known as expansion path or scale line. At any particular time, only one expansion path is possible.

Ridge lines or Border or Boundary lines

Ridge lines represent the points of maximum output from each input, given a fixed amount of another input. Also they represent limits of substitution. Ridge lines reflect the limits of economic relevance, the boundaries beyond which isoquant map ceases to have economic meaning. The portions of isoquants which lie between the lines are suited for economic production (Where MPP of both inputs are positive but decreasing and isoquants are negatively sloped). Portions of is oquants outside the ridge lines are not suitable for production in economic terms (outside the ridge lines, MPP of both factors are negative and methods of production are inefficient).



Product-Product Relationship

- Product-Product relationship deals with resource allocation among competing enterprises.
- The goal of Product-Product relationship is profit maximization.
- Under Product-Product relationship, inputs are kept constant while products (outputs) are varied.
- This relationship guides the producer in deciding 'What to produce'
- This relationship is explained by the principle of product substitution and law of equi marginal returns.
- This relationship is concerned with the determination of optimum combination of products (enterprises).
- The choice indicators are substitution ratio and price ratio.
- Algebraically it is expressed as

$$Y_1 = f(Y_2\ Y_3, \ldots\ldots. Y_n)$$

Production Possibility Curve (PPC)

Production Possibility Curve is a convenient device for depicting two production functions on a single graph.

Def: Production Possibility Curve represents all possible combinations of two products that could be produced with given amounts of inputs.

Production Possibility Curve is known as Opportunity Curve because it represents all production possibilities or opportunities available with limited resources.

It is called Isoresouce Curve or Iso factor curve because each output combination on this curve has the same resource requirement.

It is also called Transformation curve as it indicates the rate of transformation of one product into another.

How to draw Production Possibility Curve

Production Possibility Curve can be drawn either directly from production function or from total cost curve.

The method of drawing Production Possibility Curve from Production Function is explained below:

A farmer has five acres of land and wants to produce two products Viz cotton (Y_1) and Maize (Y_2). Assume all other inputs are fixed. Now the farmer has to decide how much of land input to use on each product.

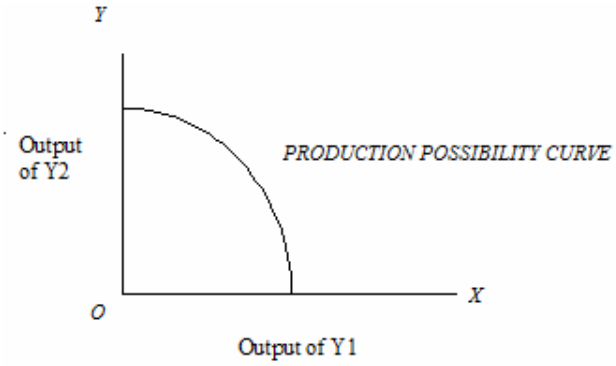
The amount of land that can be used to produce Cotton (Y_1) depends upon the amount of land used to produce Maize (Y_2)

Therefore $Y_1 = f(Y_2)$

The allocation of land resource between the two products and the output from different doses of land input are presented below

Allocation of land in acres		Output in quintals	
Y_1	Y_2	Y_1	Y_2
0	5	0	60
1	4	8	48
2	3	15	36
3	2	21	24
4	1	26	12
5	0	30	0

As evident from the above data, if all 5 acres of land are used in the production of Y_2 we obtain 60 quintals of Y_2 and do not get any Y_1. On the other hand, if all the five acres of land are used in the production of Y_1 we can obtain 30 quintals of Y_1 and do not get any Y_2. But these are the two extreme production possibilities. In between these two, there will be many other production possibilities. Plotting these two points on a graph, we get the Production Possibility Curve.



Production Possibility Curve

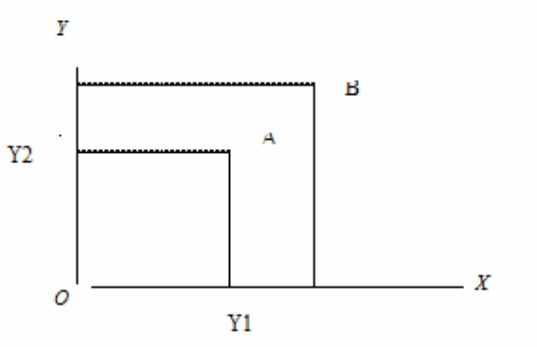
Types of Product-Product Relationships or Enterprise Relationship

Farm commodities bear several physical relationships to one another. These basic product relationships can be

1) Joint Products: These are produced through single production process. As a rule the two are combined products. Production of one (main product) without the other

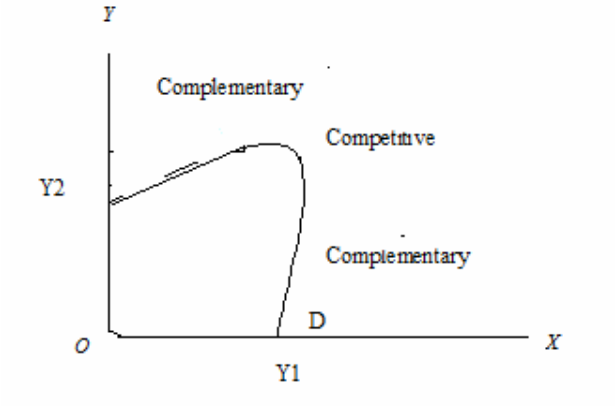
(by-product) is not possible. The level of production of one decides the level of production of another. All farm commodities are mostly joint products.

Ex: Wheat and Straw, paddy and straw, groundnut and hulms , cotton seed and lint, cattle and manure, butter and buttermilk, beef and hides, mutton and wool etc.



Graphically the quantities of Y1 and Y2 that can be produced at different levels of resources will be shown as points AB in the figure.

2) Complementary enterprises: Complementarity between two enterprises exists when with a change in the level of production of one, the other also changes in the same direction. That is when increase in output of one product, with resources held constant, also results in an increase in the output of the other product. The two enterprises do not compete for resources but contribute to the mutual production by providing an element of production required by each other. The marginal rate of product substitution is positive (> 0). Ex: Cereals and pulses, crops and livestock enterprises.



As shown in the figure, range of complementarities is from point A to point B when production of Y1 expands beyond zero level. On the other end of the curve, the products again are complementary as production of Y2 expands beyond zero. This

means Y1 must be produced up to B and Y2 up to point C , up to these points increase in one product increases the production of other.

All complementary relationships should be taken advantage by producing both products up to the point where the products become competitive.

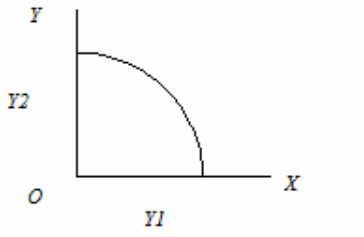
3) Supplementary enterprises: Supplementarity exists between enterprises when increase or decrease in the output of one product does not affect the production level of the other product. They do not compete for resources but make use of resources when they are not being utilized by one enterprise. The marginal rate of product substitution is zero.

For example, small poultry or dairy or piggery enterprise is supplementary on the farm.

All supplementary relationships should be taken advantage by producing both products up to the point where the products become competitive.

Production of Y_1 can be increased without affecting the production of Y_2 in the range AB. From C to D, production of Y2 can be increased without affecting the production of Y_1.

4) Competitive enterprises: This relationship exists when increase or decrease in the production of one product affect the production of other product inversely. That is when increase in output of one product , with resources held constant, results in the decrease of output of other product.Competitive enterprises compete for the same resources. Two enterprises are competitive in the use of given resources if output of one can be increased only through sacrifice in the production of another. The marginal rate of product substitution is negative (<0)



5) Antagonistic products: Two products may be detrimental to each other because of disease or similar factors. When this is true ,only one of the products should be produced. Eg: Aqua culture and paddy cultivation.

Marginal rate of product substitution

The term marginal rate of product substitution has the same meaning under the product-product relationship as under the factor-factor relationship.

Marginal rate of the product substitution refers to the absolute change in one product associated with a change of one unit in competing product.

The quantity of one product to be sacrificed so as to gain another product by one unit is called MRPS.

MRPS = Number of units of replaced product / Number of units of added product

$MRPSY_1Y_2 = ?Y_2/?Y_1$

$MRPSY_2Y_1 = ?Y_1/?Y_2$

Types of Product Substitution

When two products are competitive, they substitute either at constant rate, or increasing rate or at decreasing rate.

1) Constant rate of Substitution:

For each one unit increase or gain in one product, a constant quantity of another product must be decreased or sacrificed.

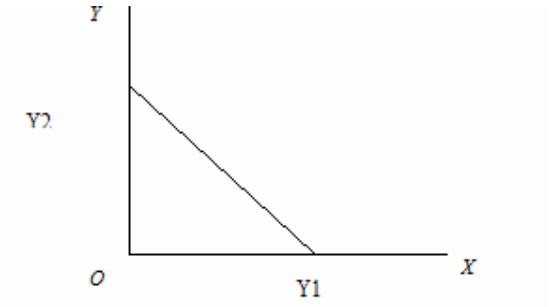
When products substitute at constant rate, the Production Possibility Curve is linear negatively sloped.

Constant rate of substitution occurs when

a) One of the production function has an elasticity greater than one (increasing returns), the other has an elasticity of less than one (decreasing returns)

Or

b) Both the production functions have stages of increasing and decreasing returns.



The Production Possibility Curve is linear when products substitute at constant rate. When two products substitute at constant rate, only one of the two products will be economical to produce depending on their relative prices. This is to say that

specialization is the general pattern of production under constant rate of product substitution.

Y_1	Y_2	$? Y_1$	$? Y_2$	MRS
0	40	--	--	--
10	30	10	10	10/10=1
20	20	10	10	10/10=1
30	10	10	10	10/10=1
40	0	10	10	10/10=1

This relationship can be expressed as

$? {}_1Y_2/? {}_1Y_1 = ? {}_2Y_2/? {}_2Y_1 = \ldots\ldots = ? {}_nY_2/? {}_nY_1$

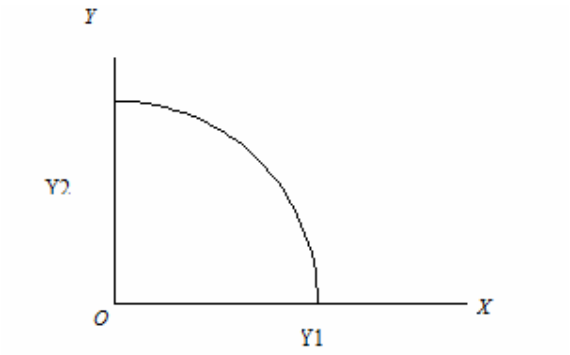
2) Increasing rate of product substitution:

Each unit increase in the output of one product is accompanied by larger and larger sacrifice (decrease) in the level of production of other product.

Increasing rates of substitution holds true when the production for each independent commodity is one of decreasing resource productivity (decreasing returns) and non-homogeneity in quality of limited resource.

The production Possibility Curve is concave to the origin when product substitutes at the increasing rate. Increasing rate of the product substitution is common in agricultural production. The general pattern of production is diversification i.e., profits are maximized by producing both the products.

$? {}_1Y_2/? {}_1Y_1 <? {}_2Y_2/? {}_2Y_1 < \ldots\ldots < ? {}_nY_2/? {}_nY_1$



Y_1	Y_2	? Y_1	? Y_2	$MRSY_1Y_2$
0	60	--	--	--
8	48	8	12	1.50
15	36	7	12	1.71
21	24	6	12	2.00
26	12	5	12	2.40
30	0	4	12	3.00

3) Decreasing rate of Product Substitution:

Each unit increase in the output of one product is accompanied lesser and lesser decrease in the production of another product.

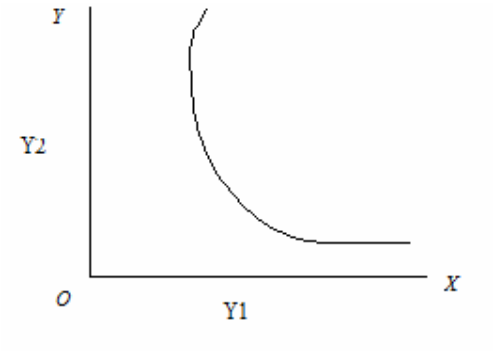
This type of product substitution holds good under conditions of increasing returns.

Production Possibility Curve is convex to the origin when products substitute at decreasing rate. It is economical to produce only one of the products depending on the relative prices, when products substitute at constant rate i.e., specialization is the general pattern of production.

Y_1	Y_2	? Y_1	? Y_2	$MRSY_1Y_2$
1	18	--	--	--
2	13	1	5	5
3	9	1	4	4
4	6	1	3	3
5	4	1	2	2

This relationship is algebraically expressed as

$? {}_1Y_2/? {}_1Y_1 > Y_2/? {}_2Y_1 > \ldots\ldots > ? {}_nY_2/? {}_nY_1$



Summary of basic Enterprise Relationships

MRPS

Relationship

1 $?Y_2/Y_1$ or $?Y_1/Y_2$ > 0 (Positive) Complementary

2 $?Y_2/Y_1$ or $?Y_1/Y_2$ =0 Supplementary

3 $?Y_2/Y_1$ or $?Y_1/Y_2$ <0 (Negative) Competitive

IsoRevenue Line

It represents all possible combination of two products which would yield an equal (same) revenue or income.

Characteristics:

1) Isorevenue line is a straight line because product prices do not change with quantity sold.

2) As the total revenue increases, the isorevenue line moves away from the origin since the total revenue determines the distance of it from the origin.

3) The slope indicates ratio of product (output) prices. As long as product prices remaining constant, the isorevenue line showing different total revenues are parallel. But change in either price will change the slope.

Determination of optimum combination of products:

1) Algebraic Method:

There are three steps to determine the optimum product combination through algebraic method.

a) Compute Marginal Rate of Product Substitution

MRPS =Number of units of replaced products/Number of units of added product

$MRPS_{Y1Y2} = ?\ Y_2/?\ Y_1$

$MRPS_{Y2Y1} = ?\ Y_1/?\ Y_2$

b) Workout price ratio (PR)

Price Ratio (PR) = Price per unit of added product/Price per unit of replaced product

$PR = P_{y1}/P_{y2}$ if it is MRS_{Y1Y2}

P_{y2}/ P_{y1} if it is MRS_{Y2Y1}

c) Optimum combination of enterprises is at where MRS=PR

$$\frac{\text{Number of units replaced product}}{\text{Number of units of added product}} = \frac{\text{Price per unit of added product}}{\text{Price per unit of replaced product}}$$

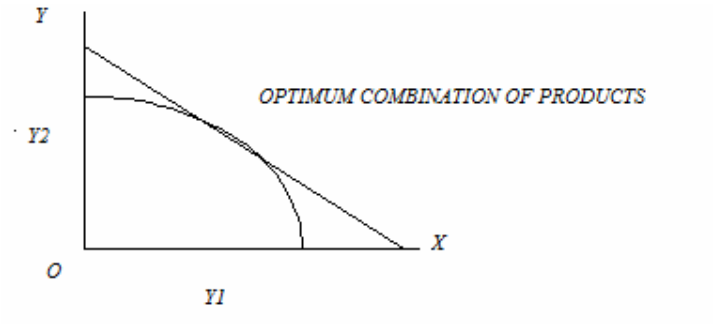
$$?\ Y_2/?\ Y_1 = P_{y1}/P_{y2}$$

Or

$$?\ Y_1/?\ Y_2 = P_{y2}/ P_{y1}$$

For profit maximization, a rational producer should operate in the range where two products are competitive and within the range, the choice of products should depend upon the MRS and PR.

2) Graphic Method:



Draw production possibility curve and isorevenue line on one graph. Slope of production possibility curve indicates MRPS and the slope of isorevenue line indicates price ratio of products. The point of optimum combination of products is at where the isorevenue line is tangent to the production possibility curve. At this point, slope of the isorevenue line and the slope of the production possibility curve will be the same. In other words, the MRPS=PR.

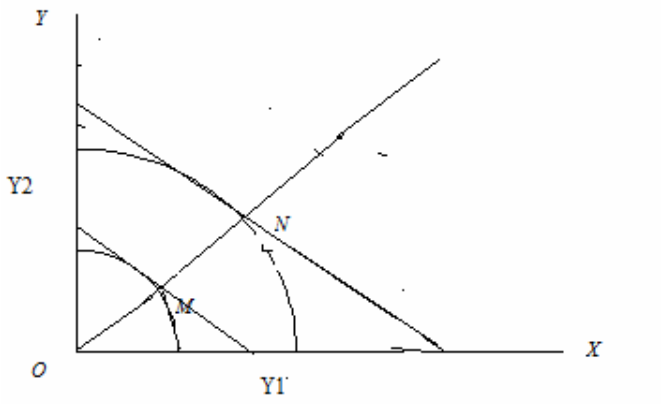
3) Tabular Method:

Compute total revenue for each possible output combination and then select that combination of outputs which yields maximum total revenue. This method is useful only when we have few combinations.

Y_1	Y_2	P_{y1}@Rs.50	P_{y2}@Rs.80	Total revenue
8	2	400	160	560
5	3	350	240	490
6	4	300	320	620
4	5	200	400	600
3	7	150	560	710

3 units of Y_1 and 7 units of Y_2 yield maximum revenue

Expansion path in Product-Product relationship

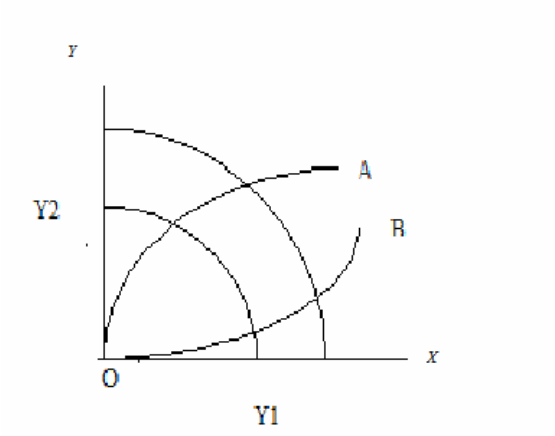


Several isorevenue lines are shown each indicating a different level of revenue. Prices are assumed constant and hence the slope of isorevenue lines remains the same. All the isorevenue lines are tangent to the production possibility curve at different points m,and n. The line connecting the points of optimum combination of the products is

called expansion path. The points of tangency specify the most profitable enterprise combination for different possibility curves with the prices indicated by isorevenue line.

Ridge lines or border lines

Line OA intersects the each production possibility curve where the production possibility curve is horizontal. Line OB intersects each production possibility curve where it is vertical. The portions of production possibility curve falling within the ridge lines have negative slope indicating competition (MRS< 0). Portions of production possibility curve outside ridge line have positive slope indicating Complementarity (MRS> 0). On the ridge lines MRS is zero. Therefore ridge lines are used to separate ranges of product competition from ranges of product complementarity.



Summary of basic production relationships

Factor – Product	Factor – Factor	Product – Product
Deals with resource use efficiency	Deals with resource combination and resource substitution	Deals with resource allocation among enterprises
Optimization of the production is the goal	Cost minimization is the goal	Profit optimization is the goal.
How much to produce	How to produce	What to produce
Considers single variable production function	Inputs or resources varied keeping the output constant	Output of products are varied keeping the resource constant
Guides in the	Concerned with the	Helps in the determination

determination of optimum input to use and optimum output to produce	determination of Least cost combination of resources	of optimum combination of products
Price ratios are choice indicator	Substitution ratio and choice ratio are the choice indicators.	Substitution ratio and price ratios are choice indicators
Explained by the law of diminishing returns	Explained by the principle of factor substitution	Explained by the principle of product substitution and law of equimarginal returns.
$Y=f(X_1 \mid X_2, X_3 \ldots\ldots\ldots X_n)$	$Y = f(X_1 X_2 / X_3 X_4 \ldots\ldots X_n)$	$Y1=f(Y_2 Y_3, \ldots\ldots. Yn)$

Returns To Scale

By returns to scale, it is meant the behaviour of production when all factors (inputs) are increased or decreased simultaneously in the same proportion.

Scale relationship refers to simultaneous change in all the resources in the same proportion. In other words, in returns to scale, we analyze the effect of doubling, trebling and so on of all inputs on the output.

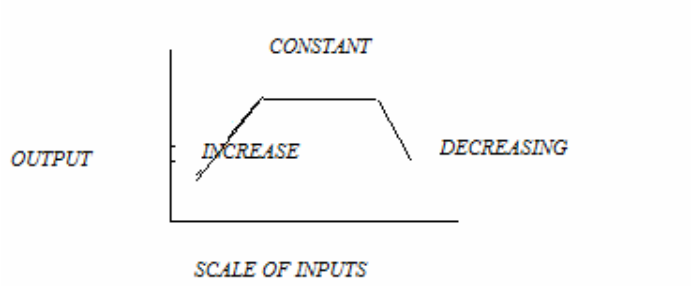
In returns to scale, all the necessary factors of production are increased or decreased to the same extent so that what ever the scale of production, the proportion among the inputs remain the same.

When all inputs are increased, in unchanged proportions, the scale of production is expanded, the effect on output shows three stages:

Firstly, returns to scale increase because the increase in total output is more than proportional to increase in all inputs.

Secondly, returns to scale become constant as the increase in total product is an exact proportion to the increase in inputs.

Lastly, returns to scale diminish because the increase in output is less than proportionate to increase in inputs.



Returns to scale-Example

SNO	Scale of inputs	Total Physical Product in Quintals	Marginal Physical Product in Quintals	Remarks
1	1 Worker+3 acres	2	2	
2	2 Workers+6 acres	5	3	Increasing Returns
3	3 Workers+9 acres	9	4	
4	4 Workers+12 acres	14	5	
5	5 Workers+15 acres	19	5	
6	6 Workers+18 acres	24	5	Constant Returns
7	7 Workers+21 acres	28	4	
8	8 Workers+24 acres	31	3	Decreasing Returns
9	9 Workers+27 acres	33	2	

In the above example, we see that when we employ one worker on three acres of land, the total product is 2 quintals. Now to increase the output, we double the scale, but the total product increases to more than double (5 quintals instead of 4 quintals). When the scale is trebled, the total product increases from 5 quintals to 9 quintals- the increase this time being 4 quintals as against 3 quintals. In other words, returns to scale have been increasing. If the scale of production is further increased, the Marginal Physical Product remains constant up to certain point and beyond it starts diminishing.

Returns to scale are more theoretical interest than being relevant to actual practice. In practice, it is the law of variable proportions which has universal applications.

Returns to scale can also be explained by using the knowledge of scale line and that of isoquant map. In the case of constant returns to scale , the distance between successive isoquants is constant i.e., AB = BC = CD (Fig-A). The distance goes on widening between the successive isoquants and diminishing returns operate i.e., AB<BC< CD (Fig-B). Finally, in the 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 -C)

Returns to scale is frequently measured by fitting the least square Cobb-Douglas production function and then adding the exponents which are production elasticities of the inputs.

$$Y= a\, x_1^{b_1}\, x_2^{b2}\, x_3^{b3} \ldots\ldots\ldots Xn^{bn}$$

Where Y= Total output

X_1, X_2, X_3 …… Xn: variable inputs

b_1, b_2, b_3…….bn: elasticity coefficients

Returns to scale from this production function are given by the summation of individual elasticities of coefficients.

Returns to scale: $\sum b_i$ where i=1 to n

$\sum_{i=1}^{n} b_i < 1$ Decreasing returns to scale

$\sum_{i=1}^{n} b_i = 1$ Constant returns to scale

$\sum_{i=1}^{n} b_i > 1$ increasing returns to scale

Differences between Law of variable Proportion and Returns to scale

Law of Variable Proportion	Returns to Scale
Describes the response in output when a single input is varied	Examines the response in output when all inputs are varied in equal proportions
At least one factor is kept constant or fixed	All factors are varied
Factors are combined in different proportions	Proportion among factors remains the same
Short run production function	Long run production function
$Y=f(X_1 \mid X_2, X_3 \ldots\ldots\ldots X_n)$	Y=f (X1,X2,X3,…..Xn)
Output exhibits three stages: increasing, constant, diminishing Increasing returns are due to better use of fixed factors	Output exhibits three stages: increasing, constant and diminishing returns to scale. Increasing returns are due to the appearance of internal economics
Maximum output is due to the best proportion between fixed and variable factors	Maximum output is due to the optimum size of production.
Diminishing returns are due to inefficiency arising out of over utilization of fixed factors beyond the optimum point.	Diminishing returns to scale are due to internal dis economies of scale.

Formulae

1. **Production function:** $y = f(x_1, x_2, x_3, \ldots x_N)$

where y is output of a crop, $x_1, x_2, x_3, \ldots x_N$ are inputs, f denotes function of

2. **Linear production function** $y = a + bx$

where y is dependent variable (output), a is constant, b is coefficient, x is independent variable (input)

3. **Cobb-douglas** (non linear production function) $y = ax^b$

where y = dependent variable, a constant, b coefficient, x independent variable

4. **Quadratic function** $y = a + bx - cx^2$

where y = output or yield dependent variable, a constant, c & b coefficient, x input (independent variable)

5. **Law of increasing returns**: $\frac{?\,Y_1}{?\,X_1} < \frac{?\,Y_2}{?\,X_2} < \cdots\cdots < \frac{?\,Y_n}{?\,X_n}$

6. **Law of constant returns**: $\frac{?\,Y_1}{?\,X_1} = \frac{?\,Y_2}{?\,X_2} = \cdots\cdots = \frac{?\,Y_n}{?\,X_n}$

7. **Law decreasing returns**: $\frac{?\,Y_1}{?\,X_1} > \frac{?\,Y_2}{?\,X_2} > \cdots\cdots > \frac{?\,Y_n}{?\,X_n}$

8. **Marginal physical product (MPP)**

$$\text{MPP} = \frac{\text{Change in total physical product}}{\text{Change in input level}}$$

$$\text{MPP} = \frac{?\text{TPP}}{?\,X} = \frac{?\,Y}{?\,X}$$

9. **Average products (AP)** $= \frac{\text{Total output}}{\text{Quantity of input}} = y/x$

10. **Marginal value product (MVP)**

$$\text{MVP} = \frac{\text{Change in total value product}}{\text{Change in input level}}$$

$$\text{MPP} = \frac{?T \cdot P_y}{?X}$$

11. **Marginal factor cost (MFC) or marginal input cost (MIC)**

$$MVP = \frac{\text{Change in total input cost}}{\text{Change in input level}} = \frac{?X \cdot P_X}{?X} = P_X$$

12. **Marginal Revenue (MR)**

$$MR = \frac{\text{Change in total revenue}}{\text{Change in output level}} = \frac{?Y}{?Y} P_y = P_y$$

13. **Marginal Cost (MC)**

$$MC = \frac{\text{Change in total cost}}{\text{Change in output level}} = \frac{?X \cdot P_X}{?y}$$

14. **Marginal Rate of technical substitution (MRTS) or Marginal Rate of substitution (MRS)**

$$\textbf{MRS} = \frac{\text{Number of units of replaced resource}}{\text{Number of units of Added resource}}$$

$$MRS_{x_1x_2} = \frac{?X_2}{?X_1}$$

$$MRS_{x_2x_1} = \frac{?X_1}{?X_2}$$

15. **Marginal Rate of product substitution (MRPS) or Marginal Rate of substitution (MRS)**

$$MRPS = \frac{\text{Number of units of replaced product}}{\text{Number of units of Added product}}$$

$$MRS_{y_1y_2} = \frac{?Y_2}{?Y_1}$$

$$MRS_{y_2y_1} = \frac{?Y_1}{?Y_2}$$

16. **Price ratio of factor (PR)**

$$PR = \frac{\text{Price per unit of added resource}}{\text{Price per unit of replaced product}}$$

$$PR = \frac{P\ X_2}{P\ X_1} \text{ or } \frac{P\ X_1}{P\ X_2}$$

17. **Product price ratio (PR)**

$$PR = \frac{\text{Price per unit of added product}}{\text{Price per unit of replaced product}}$$

$$PR = \frac{P\ Y_2}{P\ Y_1} \text{ or } \frac{P\ Y_1}{P\ Y_2}$$

18. **Constant rate of factor substation**

$$\frac{?_1\ X_2}{?_1\ X_1} = \frac{?_2\ X_2}{?_2\ X_1} = \ldots\ldots = \frac{?_n\ X_2}{?_n\ X_1}$$

19. **Decreasing rate of factor substitution**

$$\frac{?_1\ X_2}{?_1\ X_1} > \frac{?_2\ X_2}{?_2\ X_1} > \ldots\ldots > \frac{?_n\ X_2}{?_n\ X_1}$$

20. **Increasing rate of product substitution**

$$\frac{?_1\ Y_2}{?_1\ Y_1} < \frac{?_2\ Y_2}{?_2\ Y_1} < \ldots\ldots < \frac{?_n\ Y_2}{?_n\ Y_1}$$

21. **Constant rate of product substitution**

$$\frac{?_1\ Y_2}{?_1\ Y_1} = \frac{?_2\ Y_2}{?_2\ Y_1} = \ldots\ldots = \frac{?_n\ Y_2}{?_n\ Y_1}$$

22. **Decreasing rate of product substitution**

$$\frac{?_1\ Y_2}{?_1\ Y_1} > \frac{?_2\ Y_2}{?_2\ Y_1} > \ldots\ldots > \frac{?_n\ Y_2}{?_n\ Y_1}$$

23. **Short run production function** $y = f(x_1 / x_2, x_3 \ldots\ldots x_n)$

24. **Long run production function** $y = f(x_1, x_2, x_3 \ldots\ldots x_n)$

25. **Least cost combination of resources.**

$$\frac{\text{Number of units of replaced resource}}{\text{Number of units of added resource}} = \frac{\text{Price per unit of added resource}}{\text{Price per unit of replaced resources}}$$

$$LCC = \frac{?\ X_2}{?\ X_1} = \frac{P\ X_1}{P\ X_2} \text{ or } \frac{?\ X_1}{?\ X_2} = \frac{P\ X_2}{P\ X_1}$$

26. **Optimum combination of products**

$$\frac{\text{Number of units of replaced product}}{\text{Number of units of added product}} = \frac{\text{Price per unit of added product}}{\text{Price per unit of replaced product}}$$

$$\frac{?\ Y_1}{?\ Y_2} = \frac{P\ Y_2}{P\ Y_1} \text{ or } ?\ Y_2 / ?\ Y_1 = PY1 / PY_2$$

27. **Optimum input or profit maximizing level of input**

Marginal value product (MVP) = Marginal factor cost (MFC)

$$\frac{?\ Y}{?\ X}P_y = \frac{?\ X}{?\ X}P_x \quad \text{or} \quad \frac{?\ Y}{?\ X} = \frac{P_x}{P_y}$$

28. **Optimum output or profit maximizing level of output**

Marginal Revenue (MR) = Marginal cost

$$\frac{?\ Y}{?\ Y}P_y = \frac{?\ X}{?\ Y}P_x$$

$$P_y = \frac{?X\ .P_x}{?\ Y}$$

$\Delta Y.P_y = \Delta X.P_x$

29. **Future value of present sum (compounding)**

$FV = P\ (1 + i)^n$

FV: Future value; P: present sum (original investment); i : rate of interest; n : number of years.

30. **Present value of Future sum (Discounting)**

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

where PV: Present value; P: sum to be received in future); i : rate of interest; n : number of years.

31. **Variable cost (TVC)** $= P_{x1} \cdot X_1$

Px_1 = price per unti of X_1, X_1 = Quantity of X_1 input

32. **Total fixed cost (TFC)** $= \sum_{j=1}^{n} P_{x_y} X_j$ (j = 2, 3, … w)

33. **Total cost (TC)** = Total variable cost + Total fixed cost

TC = TVC + TFC

34. **Average variable cost (AVC)** $= \frac{\text{Total variable cost}}{\text{output}}$

$$AVC = \frac{TVC}{Y}$$

35. **Average fixed cost (AFC)** $= \frac{\text{Total fixed cost}}{\text{output}}$

$$AVC = \frac{TFC}{Y}$$

36. **Average total cost (ATC)** = $\frac{\text{Total cost}}{\text{output}}$

or

Average total cost (ATC) = Average variable cost + Average fixed cost

? TC = AVC + ATC or $\frac{TC}{Y}$

37. **Cost A_2** = Cost A_1 + Rent on leased in land

38. **Cost B** = Cost A_1 / A_2 + Rent on owned land + Interest on owned fixed capital

39. **Cost C** = Cost B + Value of family labour

40. **Farm business income** = Gross income – Cost A_1 / A_2

41. **Family labour income** = Gross income – Cost B

42. **Net income** = Gross income – Cost C

43. **Farm investment income** = (Gross income – Cost C) + (Cost B – Cost A)

44. **Net cash income** = Total cash income – Total cash operating expenses

45. **Net Farm income** = Net cash income + Change in inventory and depreciation

46. **Farm earning** = Net farm income + Value of farm products consumed in home

47. **Family labour earnings** =Farm earnings – Interest on capital

48. **Returns to management** = Family labour earnings - Value of family labour

49. **Operating cost ration (OCR)** = $\frac{\text{Operating expenses}}{\text{Gross income}}$

50. **Fixed cost ratio (FCR)** = $\frac{\text{Total fixed costs}}{\text{Gross income}}$

51. **Gross cost ratio (GCR)** = $\frac{\text{Total costs}}{\text{Gross income}}$

52. **Rate of capital turnover** = $\frac{\text{Gross income}}{\text{Total capital invested}}$

53. **Net capital ratio (NCR)** = $\frac{\text{Total assets}}{\text{Total liabilities}}$

54. **Working ratio (WR)** = $\frac{\text{Current assets + Working assets}}{\text{Current liabilites + Working liabilities}}$

55. **Current ratio (CR)** = $\frac{\text{Current assets}}{\text{Current liabilites}}$

56. **Debt/equity ratio** = $\frac{\text{Total liabilites}}{\text{Owner's equity or net woth}}$

57. **Production efficiency** =

$$\frac{\text{Yield of a crop on the farm}}{\text{Average yield of the same crop in the locality}} \times 100$$

58. **Cropping intensity** = $\frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$

59. **Productive man work units per mar equivalent**

$$\frac{\text{Total productive man work units}}{\text{Number of man equivalents}}$$

60. **Straight line method** = $\frac{\text{Original cost - Junk value}}{\text{Useful life}}$

61. **Diminishing balance method** = (Book value at the biginning) x R

where R is rate of depreciation

62. **Sum of the years digits method** = (Original cost – Junk value) X $\frac{RL}{SoYD}$

RL : Remaining years of useful life

SoYD : Sum of the years digits

63. **Income capitalization** V = R / r

where V = capitalized value, R = Net income per unit of land per annum, r = rate of interest

64. **Break-even output** =

$$\frac{\text{Total Fixed costs}}{\text{Seeling price per unit} - \text{Variable costs per unit (AVC)}}$$

ABBREVIATIONS

1.	PF	:	Production Function
2.	EP	:	Elasticity of production
3.	SRPF	:	Short run production function
4.	LRPF	:	Long run production function
5.	TP	:	Total Product
6.	MP	:	Marginal product
7.	AP	:	Average Product
8.	TPP	:	Total physical product
9.	APP	:	Average physical product
10.	MPP	:	Marginal physical product
11.	TVP	:	Total value product
12.	AVP	:	Average value product
13.	MVP	:	Marginal value product
14.	MFC	:	Marginal factor cost

15.	MIC	:	Marginal input cost
16.	MC	:	Marginal cost
17.	MRS	:	Marginal rate of substitution
18.	MRTS	:	Marginal rate of technical substitution
19.	MRPS	:	Marginal rate of product substitution
20.	PR	:	Price ratio
21.	TFC	:	Total fixed cost
22.	TVC	:	Total variable cost
23.	TC	:	Total cost
24.	AFC	:	Average fixed cost
25.	AVC	:	Average variable cost
26.	ATC	:	Average total cost
27.	PPC	:	Production possibility curve
28.	LCC	:	Least cost combination of resources
29.	LDR	:	Law of diminishing returns
30.	LEMR	:	Law of equi-marginal returns.
31.	CYI	:	Crop yield index
32.	CI	:	Cropping intensity
33.	GI	:	Gross income
34.	NI	:	Net income
35.	PMWC	:	Productive man work unit
36.	BEO	:	Break-even output
37.	BEP	:	Break-even point
38.	NCR	:	Net capital ratio
39.	WR	:	Working ratio
40.	CR	:	Current ratio
41.	MR	:	Marginal revenue
42.	OCR	:	Operating cost ratio
43.	FCR	:	Fixed cost ratio
44.	GCR	:	Gross cost ratio
45.	FBI	:	Farm business income
46.	FLI	:	Family labour income
47.	LP	:	Linear programming