

1. Section one

Farm management science

Agriculture is the art and science of cultivating crops, raising livestock, provision of raw materials for industries and agricultural products for man's use. There are many branches of agriculture which among others include: agricultural economics, crop science, soil science, animal science, fishery, forestry and agricultural engineering.

How agriculture could be both a science and An Art?

- Agriculture is both a science and an art.
- In science, you need an inquisitive mind that observes behaviors or properties, identifies positive and negative outcomes of different activities and seeks solutions or even creates solutions using that knowledge.
- Agriculture involves all of this including solving matrixes, mathematical calculations, measurements, research among all other scientific concepts.

So Agriculture is a science!

- **In Art**, you need an imaginative mind that can create visual images and express these imaginations in form of some hands-on technical skill which people can see and appreciate.
- Agriculture many times involves envisioning things that are not in existent yet but able to use that imagination to bring to life new ideas that can be researched upon and used to create solutions.
- 2 examples: the use of polythene bags as a planting material. As an artist, a farmer imagined that solution for crops. Secondly, mapping out a farmland, a farmer can draw out his farmland to make proper planning for each season cultivation

- Therefore a successful agricultural entrepreneur must have a mix of both scientific and artistic skills

Agricultural economics involves the application of economic principles in agriculture. One of the important branches of agricultural economics is farm management. Generally speaking, management is the ability of some people to compel economic progress through other people's efforts. When applied to farm business, management could be seen as a practice

undertaken of the farm business with respect to production of crops and livestock as a means of obtaining high profit.

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. Hence, welfare of a nation depends upon accomplishments of each farm unit. 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 of improved technology. Human race depends more on farm products for their existence than anything else since food, clothing – the prime necessities are products of farming industry. Even for industrial prosperity, farming industry forms the basic infrastructure. Thus the study of farm management has got prime importance in any economy particularly in the agrarian one.

1.1. Definition and concepts of 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 center 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 organization 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 mechanized, 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 necessities 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.

1.2 DEFINITIONS OF FARM MANAGEMENT

1. The art of managing a Farm successfully, as measured by the test of profitability is called farm management. (L.C. Gray)
2. Farm management is defined as the science of organization 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 organization 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 organization and operation of the individual farm unit for securing the maximum possible net income. (Bradford and Johnson)

1.3. Objectives and Scope of Farm Management

The central theory of farm management is the theory of optimal decision-making in the organization and operation of a farm for profit maximization. To this end, the objectives and scope of farm management are discussed as follows:

1.3.1 Objectives of Farm Management

Looking at the farm structure as a whole, it is apparent that the objective of farm management are those that have to do with the two aspects of the same farm as a producing unit and as a consuming unit along with the harmonization of their behavior and goals. Broadly speaking the objectives of farm management are:

- To study the existing resources-land, labor, capital and management-and the production pattern on the farm.

- To perform the strategic task of finding out the deviation of the resources from their optimum utilization.
- To explain the means and the procedure of moving from the existing combination of resources to their optimum use for profit maximization.
- To outline conditions that would simultaneously obtain its objectives of profit maximization and maximization of family satisfaction through optimum use of resources and judicious income distribution.
- To workout costs and returns on individual enterprises and on the farm as a whole.

1.3.2 Scope of Farm Management

Farm management is generally considered to fall in the field of microeconomics. That means, in a way concerned with the problems of resource allocation in the agricultural sector, and even the economy as a whole, the primary concern of farm management is the farm as a unit. It deals with the allocation of resources at the level of an individual farm. It covers the whole aspects of individual farm business which have bearing on the economic efficiency of the farm. These include:

- The types of enterprises to be combined/enterprise relationships
- The kinds of crops and varieties to be grown/choice of input-output combinations
- The dosage of fertilizer to be applied
- The implements to be used
- The way the farm functions are to be performed
- Investment decisions
- Appraisal of farm resources
- Farm planning and budgeting
- Farm prices, credit and profits
- Risk and uncertainty
- Planning the marketing of farm produce

All the above aspects of farm business, which fall within the purview of the subject of farm management, are so interlinked and drawn together, that is systematic study of all of them is required to understand the business of farms within the circle of scarcity and choice.

1.4. Farm management decision making process

1.4.1 Farm Decision Making Process

As indicated before, farm management is concerned with the allocation of limited resources among a number of alternative uses which requires a manager to make decisions. A manager, first, must consider the resources available for attaining goals which have been set. Limits are placed on goal attainment because most managers are faced with a limited amount of resources. Decision-making is the most important responsibility of a manager of a farm business or other type business. Decisions form the life-wire of the farm business. A successful manager is one who has the skill to choose between alternatives in a constrained environment and effective at attaining the stated objectives at best.

In a farm business, goal attainment is confined within some limits set by the amount of land, labor and capital available. These resources may change overtime, but they are never available in infinite amounts. The level of management skill available or the expertise of the manager may be another limiting resource. If the limited resources could only be used one way to produce one agricultural product, the manager's job would be much easier. The usual situation allows the limited resources to be used in several different ways to produce each of a number of different products. In this case, the manager may be faced with a number of alternative uses of the limited resources and must make decisions on how to allocate them among the alternatives to maximize profit from the total business. This is one of the reasons why decision making is mentioned in the definition of farm management. Without decision nothing would happen. Even allowing things to continue as they are implies a decision, perhaps not a good decision but a passive decision nevertheless.

The process of making a decision can be formalized into a logical and orderly series of steps. Following these steps will not ensure a perfect decision but ensure that the decision is made in a logical and organized manner.

1. **Identify and define the problem:** A manager must constantly be alert to identify problems as quickly as possible. Most problems will not go away by themselves and represent an opportunity to increase the profitability of the business through wise decision making. Once identified the problem, it should be concisely defined. Good problem definition will minimize the time required to complete the remainder of the decision making steps. Definition of the problem involves locating the root cause of the problem identified. This helps to identify factor responsible for the problem identified. For the case of low yield identified as a problem, the possible cause can include low input use such as fertilizer which may depend on several factors.

2. **Collecting relevant data and information:** Once a problem has been identified, the next step should be to gather data, information and facts, and to make observations which pertain to the specific problem.
3. **Identifying and analyzing alternatives:** Once the relevant information is available, the manager can begin listing alternatives which are potential solutions to the problem. Several alternatives may become apparent during the process of collecting data and transforming data into information. Each alternative should be analyzed in a logical and organized manner to ensure accuracy and to prevent something from being overlooked.
4. **Making decision:** Choosing the best solution to a problem is not always easy, nor is the best solution always obvious. Sometimes the best solution is to do nothing or to go back, redefine the problem and go through the decision-making steps again.
5. **Implementing decision:** Selecting the best alternative will not give the desired results unless the decision is correctly and promptly implemented. Resources may need to be acquired and organized. This requires some physical actions to be taken.
6. **Evaluation:** This is the last step in the process of decision making. It involves comparing the result or performance of your farming business before and after the implementation of the solution.

Classifying Decision

Decision made by farm manager can be classified in a number of ways. One way of classification system may be to consider decisions as either *organizational* or *operational* in nature.

Organizational decisions are those decisions made in the general areas of developing plans for the business, acquiring the necessary resources and implementing the overall plan. Some of such decisions include: decisions regarding selection of the best size of the farm, what scale should be the farm operation, decisions regarding (how much land to purchase or lease; how much capital to borrow; the level of mechanization; construction of buildings and irrigation facilities, etc.). Therefore, organizational decisions are related to planning and organization of the farm that tend to be long run decisions which gives shape to the overall organization of the farm and are not modified or reevaluated more than once a year. Compared to operational decisions, organizational decisions require heavy investment and have long lasting effect.

Operational decisions are made more frequently than the organizational decisions and related to the many details made on a daily, weekly or monthly basis and are repeated more

often than the organizational decisions as they follow the routines and cycles of agricultural production. **Operational decisions** are frequent which involve relatively lower investment and their effect is short lived. Some of such decisions include:

- Selecting fertilizer and seeding rates for a given field and year
- Making changes in livestock feed ration
- Selecting planting and harvesting dates
- Marketing decisions and daily work schedules
- What to produce (selection of enterprises)
- How much to produce (enterprise mix and production process)
- How to produce(selection of least cost method)
- When to produce (timing of production)

1.5. Farm management problems in Developing countries

Farm management problems in developing countries may vary from place to place depending largely upon the degree of agricultural development and the availability of resources. The following are some of the most common problems in the field of farm management.

Small size of farm business: The average land holding size or operational holding in developing countries like Ethiopia is very small. The land holdings are fragmented too. Excessive pressure of population creates unfavorable man-land ratio in most parts of the country. This combined with excessive family labor, which depends upon agriculture, has weakened the financial position of the farmers and limited the scope for business expansion.

Farm as a household: In most parts of the country family farms perpetuate the traditional combinations of crops and methods of cultivations. Thus the equation between agricultural labor and household labor becomes an identity. This makes difficult for the farmer to introduce business content and incorporate new management idea in his farm operations. Home management, thus, heavily influences and gets influenced by farm decisions

Inadequate capital: Capital shortage is peculiar feature of farming in developing countries. Most often, peasant agriculture (which is mostly subsistence) is labor intensive and characterized by serious deficiency of capital. Generally small size of farms, problems of tenure ship and remunerative prices have set the farmer under perpetual poverty. New technologies demand higher inputs such as more fertilizers, plant protection measures, irrigation and better seeds as well as investment in power and machinery. Small farmers

cannot meet the financial requirements from their own funds. Hence, low cost, adequate and timely credit is their most pressing need if they have to put their firm-farms on growth paths.

Under-employment of factors of production: Underemployment of factors of production in developing countries emanate from: small size of the farms, large family labor supply, seasonal nature of production, lack of subsidiary or supporting rural industries, etc.

Slow adoption of innovations: Small farmers are usually conservative and sometimes skeptical of new technologies and methods. The rate of adoption, however, depends; largely on the farmers' willingness and ability to use the new information (once they get it effective they will become eager to adopt it). However, since established attitudes and values do not change overnight the extension efforts take time to get the research results commercially adopted and existed on the farms. It calls for training and substantial financial requirements.

Inadequacy of input supplies: Farmers may be willing to introduce change yet they may face the difficulty in obtaining the required inputs of required quality, in sufficient quantity, and on time to sustain the introduced changes. Shortages of foreign exchange in developing countries seriously limit importation of needed supplies and materials. Domestic industries generally lack raw materials, skills, capital or combination of these to manufacture the needed farm supplies or inputs.

Managerial skill: The most important and difficult problem for many years has been the managerial skills of large number of small-scale farmers in the country. This is necessary to make millions of ultimate users of research results develop progressive attitudes and be responsive to the technological changes. Education of the farmers on a mass scale is, thus most important. Even illiterate people can be educated through demonstration of the application of new techniques and better uses of the inputs available.

Communication and markets: These are two important elements of infrastructure necessary for introducing economic content in the farm organizations. Lack of adequate communication systems and the regulated market organization stand as a major bottleneck in the way of improving the management of farms on business lines. Substantial investments therefore need to be made on roads, marketing systems, and other communication facilities in almost all parts of the country.

Characteristics of Farming as a Business

Farming as a business has many distinguishing features from most other industries in its management methods and practices. The major differences between farming and other industries are:

- a. **Primary forces of production:** Agriculture is primarily biological in nature. A slight change in the environment may cause serious difficulties. One day of cold, for example, may destroy the whole of a standing crop. Unforeseen changes in the environment such

as plant or animal diseases and storm can cause a considerable damage. Most of the other industries are less likely to be affected by such circumstances.

- b. **Size of the production unit:** Farming is a small-sized business as it gives little scope for division of labor. In this business the farmer is both the laborer and the capitalist.
- c. **Heavy dependence upon climatic factors:** Weather changes may involve readjustments. As a result of dependence on climatic factors, management practices in farming must be much more flexible than in other industries.
- d. **Frequency and speed of decisions:** Farming requires many and speedy decisions on the part of the farmer and the farm workers.
- e. **Changes in prices:** Agricultural prices and production usually move in opposite directions. Because of the effects of climate and biological factors, a relatively large volume of production of a given farm commodity is usually followed by a decrease in price, and a smaller volume results in increase in prices.
- f. **Fixed and variable costs:** Of the total costs, portion of fixed costs is more in agriculture than in other industries. This high proportion of fixed costs tends to make the adjustments in production more difficult.
- g. **Inelastic demand for farm products:** Agriculture deals with production of food and raw materials. As standard of living improve and income increases, the demand for agricultural products will increase less rapidly than that for industrial products. On the one hand, if increased production comes from the decreased marginal returns phase, costs will go high. Higher production may reduce prices so low that total returns might not increase or even may decrease.

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Section -two

2. Production Resources and Management

Pre-test questions

- What are the basic factors of production?
- Mention the reward for basic factors of production..
- Give examples for fixed resources and variable resources.
- How farmers decide on the value of their resources at a point in time (e.g. during selling)
- What is depreciation?

Farm Resources

Productive resource is any good (commodity) or service used in the production process to create another good (commodity) or service. In the production process, firms use factors (inputs or agents of production) which are often classified into four categories: land, labor, capital and entrepreneurship.

Land: It consists of those gifts of nature which are not the result of human effort and it includes land, water, sunshine, natural forests, minerals, wild animals and local climate. It is often made productive as a result of human effort. Land is the basic resource which supports the production of all agricultural commodities with unique characteristics compared to other resources. The specific characteristics of land include:

1. **Land doesn't depreciate or wear out** provided that soil fertility is maintained and appropriate conservation means are used.
2. **Area space and location of land are immobile:** that is land cannot be moved or shifted to be combined with other resources such as machines, seed, fertilizer or water, rather the latter have to move to the land in the production of crops or livestock.

3. **Each farm or specific parcel of land is unique:** each parcel of land contains one or more distinct features such as soil types, topography, climatic factors and the existence of natural hazards such as flooding, wind, etc.
4. **Land is said to be fixed and limited in quantity (Supply):** this is to say that the area of land at country level cannot be increased or decreased (supply of land is fixed) but for an individual farmer, land can be increased or decreased.

Therefore a farm manager should use these unique qualities of land for proper decision making to make the farm enterprise perform well.

Labor: The term labor describes the effort of human beings that include hired labor, family labor and farmers' labor. Labor is needed for every type of production. It can be more productive as a result of time and effort devoted to training.

The amount of labor (the labor input) used over a particular farm or plot of land depends on the number of individuals employed and the number of hours worked. Mostly labor is measured in man-day, where one man-day is equal to 8 hrs of work for an average man with average strength, skill and experience. The most important characteristics of labor useful for managerial decisions include:

1. Labor is a flow resource that it cannot be stored like seed or labor is available for specified time.
2. It is the service that is hired or purchased not the labor unlike land and capital items, i.e. the worker sells his/her work or services.
3. Labor is a lumpy or indivisible input. This is to say that it is not possible to employ half a man (but possible to divide seed or fertilizer).
4. In agricultural sector, the operators and other members of the family provide all or largest part of labor in a farm. This labor (family or community labor) doesn't generally receive direct cash payment unlike manufacturing sector, so its costs and values can be easily overlooked or ignored.
5. The human factor is another characteristic distinguishing labor from other resources. That is if an individual employee is treated as an inanimate object, productivity and efficiency suffers. Therefore, the hopes, fears, ambitions, likes and dislikes, worries and personnel problems of the owner/operator and the employees must be considered in any labor management plan.

Capital: It presents all resources which are the result of past human effort. Which means it consists of all manmade goods which are used in the production of other goods. The capital category includes a wide variety of items ranging from durable items such as buildings, dams, roads, and machinery to stock of materials like seed and fertilizer which may be used in a single production season. Capital should not be confused with money since money itself is not a productive resource. It only becomes productive when it is used to buy physical items or hire services.

Management (Entrepreneurship): Entrepreneurship involves organizing and coordinating the different farm resources (land, labor and capital) so as to get the maximum output and profit. Management function is primarily a mental process, each choice and action whose

results are conditioned by the attitudes, values and goals of the manager. The manager's goals and value systems unconsciously determine what he will observe, what variables he will consider, what information he will gather, and which alternatives he will choose. Thus, the formulation of these goals is essential in effective management because they give direction to the whole managerial process.

Factors of production could be fixed or variable. The difference between fixed and variable factors relates to the time horizon involved. In economics, there are two main horizons: the short run and the long run. The short run is a relatively short period of time in which the quantity of some factors of production such as equipments and buildings cannot be varied. Such factors are called fixed factors. Factors of production whose quantity can be varied in the short run are called variable factors. The long run, on the other hand, is a relatively long period which allows the variation of all factors of production including plants and equipments.

Variable resources in summary:

- a. The resources whose uses 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, feeds, medicines etc., are examples of variable resources.

Fixed resources in summary:

- a. 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 types of 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: machinery, farm buildings, equipment, implements, livestock, etc.

Rewards for using farm resources

The reward for using land is rent. Rent can be paid in cash or in kind by using farm produce. Rent can be paid annually, seasonally, etc. based on the terms of agreement.

The reward for using labor is either salary or wage. It is salary for those who are on the payroll receiving monthly salaries and wage for the casual laborer.

The reward for using capital is interest (cost of using money). The rate of interest charged depends on the source of the capital. For instances private money lenders charge higher rates as compared to formal financial institutions.

The reward for using management/entrepreneur is profit. This is so because the ultimate aim of any producer is to maximize profit. Here the principle of "carrot and stick" holds. If a

manager performs well, he is given a carrot in the form of a pat on the back for a job well done or promotion or an award. On the contrary, if he fails by recording a loss or poor performance, he is given a “Stick” in form of query, dismissal, warning or demotion.

Farm Resources Valuation

Valuation is the practice of attaching prices to a given asset like buildings, vehicles, growing crops, and stored products at the end of an accounting period or at the time of sale for a particular farm organization. The price shows what farm assets worth at a particular time. Valuation process involves getting a realistic measure of the current value of the assets of the farm business. The first step in asset valuation is to list the resources available in physical terms and the second step is placing values on the assets. The five methods of valuation include are briefly explained below

Valuation at cost: This method involves entering the actual amount invested on the asset when it was originally acquired. A major set-back of this procedure is that after the business has been in operation for some time, the original cost is not of much value since the conditions might have changed at the time of valuation.

Valuation at market price: The market price of an asset at the time of consideration can be taken as its value. Example grains, feeder, livestock and land. This method may, however, over or under-estimate the value depending on the states of affairs in the economy. For instance the market price for the land may be based on the price of a similar piece of land or what the owner is willing to sell it for. Yet, it’s common phenomenon that land appreciates in value over time.

Valuation at net selling price (P_{NS}): Some costs such as cost of advertisement and transportation may incur at a time of selling an asset. In this valuation method, whatever price that can be obtained in the market for the asset, that is, market price (P_m) less the cost of selling (CS) is taken as a price of asset at a particular point in time. Mathematically it can be shown as: $P_{NS} = P_m - CS$.

Valuation by reproductive value: An asset can be valued at what it would cost to produce it at present prices and under present methods of production. This method is more useful for long-term assets and has little or no application for short-lived assets.

Cost less accumulated depreciation: This method is appropriate only for depreciable assets like machinery and buildings. Value of the asset is set equal to the ‘book value’. Book value is computed as the difference between the initial cost and the accumulated depreciation of the asset from acquisition to the time of valuation.

Depreciation

Depreciation is the loss in value of capital asset overtime due to age, obsolescence and wear and tear. Depreciation, therefore, is a function of time and use, and it involves prorating the original cost of an asset over its useful life. An important but difficult consideration is the rate at which depreciation should take place. Some managers assume 10%, 20%, etc. but the best

choice depends on the depreciation rate that is closest to the actual rate of loss in value for the period under consideration.

Three main inputs are required to calculate depreciation:

Useful life – this is the time period over which the organisation considers the fixed asset to be productive. Beyond its useful life, the fixed asset is no longer cost-effective to continue the operation of the asset.

Salvage value – Post the useful life of the fixed asset, the company may consider selling it at a reduced amount. This is known as the salvage value of the asset.

The cost of the asset – this includes taxes, shipping, and preparation/setup expenses.

Different assets loss values at different rates; hence different methods of depreciation have been developed. These methods of depreciation are discussed as follows:

Annual Revaluation Method

The annual revaluation method is based on the resale value of the asset in the market. In this approach Depreciation (D) = Original Price – Resale Price of the asset to date

If the original price of an asset was Birr 2,000 in 2009 and Birr 1,800 in 2010 the depreciation is 200 (*i.e.*, 2,000 – 1,800 = 200). The problem with this method is that it may not be easy to find a comparable product being sold in a market at a time of estimating depreciation. Or in an economy with run-away inflation, a recent experience of rising world price, appreciation rather than depreciation of assets might be apparent. For instance an asset purchased in 1975 for Birr 2,100 was sold for Birr 2,500 in 1983 because the new price of virtually the same asset has gone up to Birr 6,000.

Straight Line Depreciation Method

With the straight line depreciation method, the value of an asset is reduced uniformly over each period until it reaches its salvage value. Straight line depreciation is the most commonly used and straightforward depreciation method for allocating the cost of a capital asset. It is calculated by simply dividing the cost of an asset, less its salvage value, by the useful life of the asset.

The straight-line depreciation method assumes that an asset depreciates at a constant rate over its economic life. The method is, therefore, useful for assets that loss value constantly over their entire life. Depreciation (D) by this method is the difference between the purchase price (P) and the salvage value¹ (SV) divided by the use full life of the asset in years (n).Mathematically:

$$D = \frac{P - SV}{n}$$

¹ Salvage value is the value of an asset at the end of its economic life

Example, An asset costing Birr 4,000 initially has a salvage value of Birr 400 and expected life of 10 years. For this asset the yearly depreciation is given by $[(4000 - 400)/10 = 360]$. The depreciation schedule over years appears as shown in the table below.

Table 1: Straight line depreciation for an asset initial cost Birr 4000 and SV Birr 400 and n=10 years

Year	Depreciation	Remaining value at the end of the year
1	360	3640
2	360	3280
3	360	2920
4	360	2560
5	360	2200
6	360	1840
7	360	1480
8	360	1120
9	360	760
10	360	400

Declining Balance Method

The declining balance method assumes a fixed rate of depreciation every year. Since the value of the asset is greater at the beginning, if the rate is applied the amount of depreciation is also greater at the beginning and less at the end. The salvage value is not subtracted from the initial cost. Yet, the rate is applied to each successive remaining balance till the salvage value of an asset is reached. This method is, therefore, useful for asset which loss value fast at the beginning of its economic life. Considering rate of depreciation to be 20% annually, schedule of depreciation using the declining balance method is shown in the table below.

Table 2: Depreciation of an asset using declining balance method (Cost Birr 4000, SV Birr 400 & n=10 years)

Year	Depreciation	Remaining value at the end of the year
1	20% of 4000 = 800	3,200
2	20% of 3200 = 640	2,560
3	20% of 2560 = 512	2,048
4	20% of 2048 = 409.60	1,638.40
5	20% of 1638.4 = 327.68	1,310.72
6	20% of 1310.72 = 262.14	1,048.58
7	20% of 1048.58 = 209.72	838.86
8	20% of 838.86 = 167.77	671.09
9	20% of 671.09 = 134.22	536.87
10	20% of 536.86 = 107.37	429.50

Straight line vs. Reducing/Declining Balance Method

Sum-Of-Years Digit Method (SOYD)

Annual depreciation is given by multiplying cost less salvage value (*i.e.*, salvage value is the estimated residual value of a depreciable asset or property at the end of its useful life) by the fraction of remaining useful life (RL) to sum-of-years digit (SOYD).

$$\text{Annual depreciation} = (\text{Cost} - \text{Salvage value}) * \frac{\text{RL}}{\text{SOYD}}$$

The sum-of-years-digit (SOYD) is obtained by summing up the digits 1 to n for an asset with a useful life of n years. For example, if the useful life of an asset is 10 years the sum of the digits is given as 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 = 55. Or use simple formula below to find SOYD.

$$\text{SOYD} = \frac{n(n + 1)}{2}$$

The sum forms the denominator for the fraction while the numerator is the remaining useful years of life of the asset at the beginning of the accounting period. Thus the fraction for the first year of the asset is 10/55. For the second and third years the fractions are 9/55 and 8/55, respectively. The depreciation schedule for the asset costing Birr 4,000 and salvage value of Birr 400 is shown in the table below. In this method the asset losses values at a fairly constant rate.

Table 3: Depreciation of an asset using the sum-of-years-digits method (Cost Birr 4000, SV Birr 400 & n=10 years)

Year	Annual Depreciation	Remaining balance
1	10/55 (4000-400) = 654.55	3345.45
2	9/55 (4000-400) = 589.09	2756.36
3	8/55 (4000-400) = 523.64	2232.73
4	7/55 (4000-400) = 458.18	1774.55
5	6/55 (4000-400) = 392.73	1381.82
6	5/55 (4000-400) = 327.27	1054.55
7	4/55 (4000-400) = 261.82	792.73
8	3/55 (4000-400) = 196.36	596.36
9	2/55 (4000-400) = 130.91	465.45
10	1/55 (4000-400) = 65.45	400.00

Activities

1. What is the straight line depreciation expense for the truck that was purchased for \$30,000 with the life time of four year and has residual value of \$2000? Prepare a 4 years depreciation plan for the truck.
2. Prepare the depreciation schedule using SOYD
3. A farm business owner purchase \$45,000 of an equipment. What is the yearly and monthly straight line depreciation expense for the equipment if it has a life time of 10 years and has residual value of \$ 5,000?

Reading assignments

Double declining balance

Units-of –production depreciation

Section-- three

3 .Analysis of Farm Records and Accounts

Pre-test questions

- What are farm records?
- Mention some farm records a farmer is expected to keep on his/her farm.
- Can we conclude that a positive net farm income is a guarantee for financial success in a given farm business?

Farm Records and Accounts

Farm records are important to the financial health of the farm. Good records do not ensure the successfulness of the farm; however, success is unlikely without them. Farm records are like grade report papers students receive in higher institutions. With a farm record report, you can tell how well you are managing your business operation and you can also see the strengths and weaknesses of your farm operation.

Farm record is an account of the various activities carried out on the farm on a regular basis. Such activities include farm purchases, utilization of farm inputs, number of livestock kept and equipment procured. It also includes crop cultivated, seed planted, cultural activities carried out, quantity harvested, etc.

Types of Farm Records

There are different types of records that are important for decision-making. And there is no single widely accepted design for farm record. However any farm record has to provide the most important requirements. These most important requirements include simplicity, specificity, ease of accessing information, and comprehensible to another user. The most important farm records are discussed below.

Inventory Records: Inventory is the listing of assets owned by the farming business. The farm tools and equipment inventory contains information of the asset such as name, the year of purchase, the cost price, the expected years of life, the annual depreciation and the beginning and end of year values. The common types of farm records are production record and sales record. Farm inventory record contains list of assets owned by the farm. Examples include crop and livestock inventory records. The crop inventory record contains information concerning the quantity and value of crops at the beginning and end of the accounting period; and the livestock inventory record shows the number of each type of livestock owned and their value at the beginning and end of the accounting period.

Income or Receipts Records: Income or receipts records can be classified by enterprise with details of each transaction like product sold, units produced and total value.

Home Consumption Record: The home consumption record usually contains the product, price per unit, total weight and the value of home consumed products. In subsistence small scale farming the proportion of home consumed products out of the total production could be substantial.

The Crop and Livestock Expenses Record: The crop or livestock expense record, which is similar to the direct expense record shows date of purchases, the seller, quantity purchased, unit price and total cost.

Farm Labour Record: This often includes both family and hired labour components. On enterprise basis the number of workers, the hour spent by each person and the wage are recorded. Hired labour costs are often transferred to the general expense record.

Durable Assets Depreciation Record: It records type of asset, purchase date and condition at purchase, purchase value, expected useful life (service period), and the rate of depreciation of the asset. The methods of determining the depreciation of farm durable items is already discussed earlier. The data will help in determining the salvage value which is the value of the assets at the end of its useful life *i.e.*, scrap value.

Net Farm Profit Record: It records the values and sources of receipts (crop, livestock), value of home consumed products and the gross farm receipts for a given year.

Farm Accounting

Commercial farming involves many transactions and book keeping. Books of account present summary of records on business transactions. Accounting systems should be designed to provide information efficiently and quickly at the least cost as well as capable of offering protection to the business by exposing theft or fraud.

Types of Farm Accounts

Some farm accounts that could be prepared and kept by a farm management include balance sheet and net income statements. We will discuss these independently.

a. Balance Sheet

It is also called the net-worth statement. It shows the value of farm assets that would remain if the farm business is liquidated and all outside claims paid. It is like taking a snap shot of the business at a particular point in time. The net-worth statement sometimes gives information on the solvency of the business and is used as a basis for credit access because it shows the ability of the business to meet short-run financial demands. If the total assets exceed the total liabilities the business is solvent, that is, the greater the net-worth, the better the solvency position of the business. Components of balance sheet are given below:

Assets

An Asset is anything of value owned by a business entity. In order to ascertain the condition of a business with regard to its immediate obligations, its assets are categorized according to their liquidity. A net-worth statement requires an inventory of all properties or assets as well as records of all liabilities of the business. There are three classes of assets. These are:

- **Fixed Assets:** Are those assets which cannot be easily converted into cash to meet current obligations. Examples of fixed assets are land, buildings and other permanent improvement like fence.
- **Working Assets:** Are those assets which are used up within the production process of the business. Their values may be regarded as being transferred slowly to the products during the farm operations. They are liquidated at a faster rate than fixed assets. Examples of working assets are farm equipment (like hoes and machete), and donkeys.

- **Current Assets:** Are also called liquid assets. Examples of current assets are cash in hand bills receivable within a short time, crops and feeds in hand.

Liability

Liabilities are those legitimate claims that can be made against a business. It is useful to have classification of the liabilities that correspond to that of the assets. Liabilities are classified according to the time they become due for payment. These classifications of liability include long-term, intermediate and current liabilities.

- **Long-Term Liabilities:** Are those that will not fall due for payment in a lump sum within a short period of time. They may fall due to a period like twenty years. Examples of long-term liabilities are real estate mortgages² and long-term land leases. These are not commonly used by subsistence farmers.
- **Intermediate Liabilities:** Are those obligations that are deferred for the time being but which will be paid within a few years like five years or less. Examples of intermediate liabilities are promissory notes, obligations based on crop or livestock in the process of production and ready to mature within a few years.
- **Current Liabilities:** Are those obligations that are payable within a year. These payments when due demand the immediate attention of the farm manager.

Net-worth

The net-worth statement is supposed to show absolute equity or the amount by which assets in the business exceed its outstanding liabilities. The term “balance sheet” depicts that the total assets be equal or greater than total liabilities in case the entire business is to close down and all liabilities are to be met. The net-worth figure indicates ultimate rather than immediate solvency of the business. Ultimate solvency measures whether total assets are equal to or greater than total liabilities. When total liabilities are not covered by total assets the business is said to be insolvent or bankrupt. The size of the net-worth figure, therefore, gives the farm manager an idea of the distance of the business from solvency. The greater the net-worth means the farther away from insolvency. Immediate solvency refers to the relationship between current liabilities and current assets which can be used to pay them off if the need arises. A farmer could be immediately insolvent, that is, unable to pay its immediate debt if current, working and long-term assets do not exceed the sum of the current, intermediate and long-term liabilities.

It should be noted, however, that the effect of changes in price level on the value of permanent assets such as land, building and livestock might have a marked effect on the net worth. If the market price of a piece of item such as land increases continuously and if this is not reflected in the net-worth statement, the true net-worth has not been shown. If the net-worth statement is being used as a basis for credit, the credit worthiness of the business is understated. Therefore caution must be taken when looking at net-worth statements. Examination of the individual item to get a true picture of the financial standing of a business is necessary. Also, the net-worth does not tell the whole story. A man with larger net-worth

² An agreement by which somebody borrows money from a money-lending organization such as a bank or savings-and-loan association and gives that organization the right to take possession of property given as security if the loan is not repaid

may have more to worry about than one with a smaller net-worth. It depends largely on the ratio of total assets and liabilities in the form of obligations and the nearness of their maturity.

Table 4: Example of Balance Sheet Statement as of December 31st, 2009

Current assets	56,400	Current liabilities	54,900
Noncurrent assets	478,000	Noncurrent liabilities	173,000
Total assets	534,400	Total liabilities	227,900
		Net-worth	306,500
		Total liab. and Net-worth	534,400

Once balance sheet statement is prepared, ratio analyses can be used to drive financial control functions which include measuring performance of business, monitoring financial progress, determine trend of a farm. Ratios can be compared across types and sizes of businesses more than money value.

b. Net Income Statement

It is the statement which presents the difference between the gross receipt and total cost of production. It is also explained as the surplus resulting from business operations which could be withdrawn without reducing the future scale of the business. Sometimes it is referred to as farm income or operating statement. For the purpose of constructing the income statement, four types of record are required. These are the farm inventory, receipt records, expense records, and home consumption records. In a nutshell, the net farm income is the difference between gross receipts and total cost of production. These two components of the net income statement are explained as follows

Gross receipt: Also called the total value of product or the total output multiplied by price per unit of produce. It is composed of:

- i. Sales of capital (e.g., machinery, if any)
- ii. Sales of crops, livestock and livestock products
- iii. Change in inventory of crops, livestock and livestock products
- iv. Product consumed in home
- v. Accounts receivable
- vi. Non-farm receipts

Total cost of production: It is the sum of operating costs and fixed costs. This excludes family and operator's labour and management. These elements are excluded here because the farm and family are closely associated in a traditional agricultural setting.

Operating Costs are those costs that vary with the level of output and which need to be re-incurred at each period of the production process. Items included in the operating costs include cost of hired labour, machinery and equipment repairs & maintenance costs, crop expenses, livestock expenses, utilities (e.g., light, water, telephone, etc.), etc.

Fixed Costs are those costs that do not vary with output in the short run. They are costs that must be met whether the harvest is good or not and whether we produce or not. Items included in this cost category are: depreciation on machinery and buildings, wages of

permanent workers, interest on debt, property tax, insurance, repairs of buildings, improvement on land, etc.

Net farm income: This is the difference between total revenue (gross receipt) and total cost. It measures the return to unpaid family labour, land, capital and management. The net farm income which measures the return to unpaid family labour, operators land, labour capital and management is traditionally represented as:

$$\text{Farm income} = \text{Gross Receipts} - \text{total cost of production} + \text{change in inventory}$$

Table 5: Net income statement for year ending 31st December, 2010

Inputs	Value	Outputs	Value
Variable costs		Sales and receipts	
Seeds	50	Livestock	44
Fertilizer	150	Chickens	150
Hired labour	200	Eggs	200
Feeds	120	Cotton	600
		Groundnut	300
		Sorghum	400
Sub-total	520	Sub-total	1,694
Fixed costs		Home consumed product	
Taxes	10	Sorghum	600
Permanent staff	300	Vegetables	50
Repairing on buildings	50	Maize	420
Interest on debt	60		
Sub-total	420	Sub-total	1070
Total cost of production	940	Total farm receipts	2,764
Opening inventory		Closing inventory	
Sheep	144	Sheep	100
Chickens	150	Chickens	350
Ducks	50	Ducks	60
Grains	240	Grains	260
Fertilizer	100	Fertilizer	80
Goats	120	Goats	160
Sub-total	804	Sub-total	1,010
Change in inventory		1010 – 804 = 206	

$$\begin{aligned} \text{Net farm income} &= \text{total farm receipts} - \text{total cost of production} + \text{change in inventory} \\ &= 2,764 - 940 + 206 \\ &= \mathbf{2,030} \end{aligned}$$

Measures of Financial Success and Capital Position

Components of the net-worth statement and the net income statements of the farm business can be used to indicate the strengths and weakness of the farm business in financial terms. An important function of management is to make use of these indicators in developing new plan and learn for better performance of the farm business.

The net income defined as the gross farm income less gross farm cost. The net farm income could be improved by increasing the gross farm income or decreasing the farm costs or both. If the net farm income, however, is low the manager should examine the gross farm income which is directly related to the yield.

For some factors might be over or under utilized by the farm firm, input factors used in the production of the output need to be re-examined. The farmer being a price taker needs to improve the efficiency of use of the resources (factor inputs) at his disposal. If low gross farm income is due to low output price the demand elasticity of the product will be instrumental in determining the revenue position of the farm. Logically, the farmer might explore all possible ways of bargaining for better prices for his output through co-operatives, government legislation, etc. However, attaining higher product price does not necessarily guarantee higher gross income, for a product with inelastic demand will result in low gross income.

Also a low net farm income might be due to high cost. Examine such cost items as feeds, labour, machinery and other supplies might reveal areas of possible wastage that need to be avoided to cut down on input costs. However, if waste is minimal a different set of input package might have to be considered.

The net farm income might be misleading because it may not be a good reflection of the amount of capital, labour and management involved in the production process. It is, therefore, necessary to examine other measures of financial success such as return to labour, management, land and capital and three ratios (gross, operating and fixed) which are also obtained from the net income statement.

Measures of Financial Success

The Gross Ratio

The gross ratio (GR) is the total farm expense (TFE) divided by the gross income (GI), that is:

$$GR = \frac{TFE}{GI}$$

The total farm expenses figure is obtained by summing the operating and fixed costs. In the case of farm given above (Table 5), farm total operating cost is Birr 520 and the total fixed cost is Birr 420 and Birr 2,970 is gross income. Gross ratio (GR) = $940/2,970 = 0.32$. This ratio shows that the total farm cost was about 32% of the gross income. A less than 1 ratio is desirable for any farm business. The lower the ratio, the higher the return per dollar invested. A higher but less than 1 ratio might be tolerated for a large farm involving heavy capital investment. A greater than 1 ratio is disastrous for a farm business and might indicate over utilization of certain resources. If this happens management should consider ways of reducing costs and increasing gross income. The gross ratio measures the overall financial success of a farm. It is a long run planning tool for determining the performance of the entire farm business.

Operating Ratio

The operating ratio (OR) is the total operating cost (TOC) divided by the gross income, that is, $OR = TOC/GI$. For the typical farm with data given in Table 5 the operating ratio

calculated as: $OR = 520/2,970 = 0.17$. The operating ratio shows the proportion of the gross income that goes to pay for the operating costs. The operating cost is directly related to the farm's variable input usage. An operating ratio of 1 means the gross income barely covers the expenses on the variable inputs used on the farm. In other words, such a business could survive only in the very short run and could fold up if correct adjustments are not made to improve the usage of variable resources in terms of reducing costs and / or increasing gross income. A thorough investigation into the details of such component part will definitely help in identifying the necessary adjustments needed to correct the situation.

The Fixed Ratio

The fixed ratio (FR) is the total fixed cost (TFC) divided by the gross income (GI), that is:

$$FR = \frac{TFC}{GI}$$

Fixed ratio for the stated farm is calculated as $FR = 420/2970 = 0.14$. The ratio shows that the fixed expense is 14% of the gross income. If the fixed ratio is close to 1, some of the fixed resources are either left idle or underutilized. However, in the event that these resources are fully utilized the high fixed ratio might be due to the farmer's over estimation of the expected gross returns in his choice of enterprise or due to unpredicted biological conditions militating against yield.

Among the aforementioned ratios measuring the financial success of a farm business, the gross and the operating ratios are the most import. The gross ratio measures the ultimate solvency and success of the farm business. The decision of whether to liquidate the farm or not depends on the gross ratio figure. A greater than 1 gross ratio means that an alternative and more profitable enterprise should be considered. The operating ratio which is directly related to the variable resources is the decision making tool with regards to factor adjustments during a production period. The fixed ratio which is an indication of the percentage of the gross income accruing to the fixed resources is an exante decision tool, that is, an important decision parameter before and not during the production period.

In the traditional farm setting, the operating ratio is more important than the fixed ratio for most of the resources used are variable while fixed items are almost negligible.

Measures of Capital Position

While the measures of financial success are based solely on the income statement, the measures of capital position are based on data presented in the net-worth statement. The ratios which indicate how solvent the business is over different time periods are the current ratio, working capital ratio, net capital ratio, asset-to-debt ratio and debt-to-net worth ratio.

Current Ratio

The current ratio (CR) is defined as the current asset (CA) divided by the current liabilities (CL). Mathematically:

$$CR = \frac{CA}{CL}$$

Based on the balance sheet statement given in Table 4 the current assets worth Birr 56,400, and the current liabilities amount to Birr 54,900, hence the current ratio is $56,400/54,900 = 1.03$. The current ratio generally shows the ability of the business to meet financial obligations or its solvency. A current ratio of greater than 1 implies that the current asset is more than the amount the farm need to pay for the current liabilities. A narrow current ratio shows that problems exist especially if bills fall due for payment at the wrong time. The current ratio is often called the acid test because it is a test that can be performed quickly.

Net Capital Ratio

The net capital ratio (NCR) is defined as the total asset (TA) divided by the difference between the liabilities (TL) and the proprietor's equity (PE).

$$\text{NCR} = \frac{\text{TA}}{\text{TL} - \text{PE}}$$

This ratio shows the overall solvency of the business, and indicates changes that are possible in the future. It shows the degree of safety of the entire farm business and determines the possibility of borrowing more capital. If the proprietor's equity of the farm is Birr 100,000, the NCR is given by the total asset (TA) divided by the difference between total liabilities and the proprietor's equity (TL-PE). Which means $534,400/(227,900-100,000) = 4.18$. Total asset and Total liabilities figure are taken from Table 4. This ratio shows at a glance by how much the assets on the farm have to decline to be exceeded by the liabilities other than the proprietor's equity. A high ratio is desirable for a risky firm business. Yet, a safe ratio depends on the type of farm and the degree of uncertainty and risks involved.

Asset-to-Debt Ratio

The asset to debt ratio (ADR) is the total asset (TA) divided by the total liability (TL), that is:

$$\text{ADR} = \frac{\text{TA}}{\text{TL}}$$

The asset to debt ratio is a close approximation of the net capital ratio if the proprietor's equity is negligible. The asset-debt ratio is, however, not as useful as the net capital ratio because it may give a distorted position of the business. Using data from balance sheet statement in Table 4 the ADR is calculated as:

$$\text{ADR} = 534,400/227,900 = 2.34$$

The asset to debt ratio of 2.34, which is lower than the 4.18 calculated for the net capital ratio, indicates a less solvent capital position of the business. The larger the proprietor's equity the less useful is the asset to debt ratio for measuring the capital position of the farm business.

Debt-to-Net Worth Ratio

The debt to net worth ratio (DNR) is defined as the total liabilities (TL) divided by the net worth (NW), that is:

$$\text{DNR} = \frac{\text{TL}}{\text{NW}}$$

This ratio indicates the ease with which the proprietor can meet financial debts internally when, and if the creditors demand. A less than 1 ratio is preferred to enable the proprietor

meet his financial obligations internally. The total liabilities (current, intermediate and long-term) given in Table 4 are summed up to Birr 227,900 and the net worth was Birr 306,500. Therefore, debt-to-worth ratio is equal to $227,900/306,500 = 0.74$. This ratio of 0.74 indicates that the total liabilities were less than the value of the net worth. Hence the proprietor can meet its debts internally.

Section ---four

4.1 Production function and relationship

Pre-test questions

- What are inputs and outputs?
- Can you mention the basic production decisions in farm business?
- What does a production function represent in farm production?
- State the possible types of production relations.

4.2 Production function is defined as the technical relationship between inputs and output indicating the maximum amount of output that can be produced using alternative amounts of variable inputs in combination with one or more fixed inputs under a given state of technology. It is usually presumed that unique production functions can be constructed for every production technology. The relationship of output to inputs is non-monetary; that is, a production function relates physical inputs to physical outputs, and prices and costs are not reflected in the function.

4.2.1 Forms and Types of Production Functions

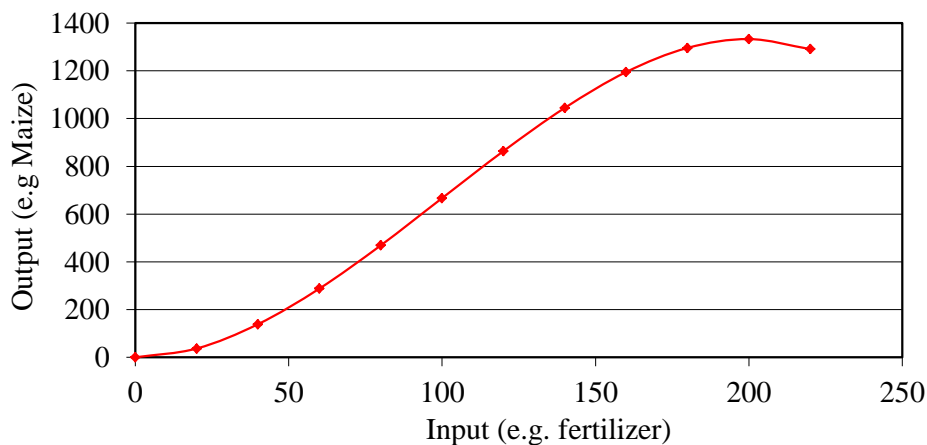
Production Function Forms

Production functions can be expressed in three forms: tabular, graphic and algebraic forms.

Tabular form: Production function can be expressed in the form of a table where one column represents input and the other indicates the corresponding total output for each input level. The two columns constitute production function.

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

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



From the graph above, we notice that:

- the production function is a continuous curve
- inputs and outputs are perfectly divisible (otherwise, it would look like a series of dots)
- inputs and outputs are homogenous

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. When all inputs in the production process individually expressed, the function is represented as $Y = f(X_1, X_2, X_3, X_4, \dots, X_n)$. In the case of single variable production function, only one variable is allowed to vary keeping others constant, the function can be expressed as:

$Y = f(X_1 | X_2, X_3, \dots, X_n)$. The vertical line used mark between variable and fixed input type. In such expression all inputs before the line represent variable type. The function

denotes that the output Y depends on the variable input X₁, with all other inputs held constant. If more than one variable input is varied and others are held constant, the relationship can be expressed as:

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

There are different functional forms to represent production function. Some of the functional forms include:

Linear production function, $Y = a + bX$

Quadratic equation, $Y = a + bX \pm cX^2$

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.

Exponential function, $Y = AX_1^{b_1} X_2^{b_2}$ -commonly known as Cobb-Douglas production function

The representation of the various symbols used in the above function is given below

Y- Dependent variable,

a - constant,

b - Coefficient,

X's - independent variable

4.2.2 Types of Production Functions

Continuous Production Function: A production function applicable for those inputs which can be split up in to smaller units. All those inputs which are measurable result in continuous production function. Example: Fertilizers, Seeds, Plant protection chemicals, Manures, Feeds, etc.

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 if inputs cannot be broken in to smaller units. Alternately stated, discrete production function is obtained for those inputs which are counted. Example: Ploughing, Weeding, Irrigation etc.

Short Run Production Function (SRPF): Production Function in which some inputs or resources are fixed. $Y = f(X_1 | X_2, X_3, \dots\dots\dots, X_n)$ Eg: Law of Diminishing returns or Law of variable proportions

Long Run Production Function (LRPF): Production function which permits variability in all factors of production. $Y = f(X_1, X_2, X_3 \dots X_n)$.

4.3. Production Relations

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 or means by which the problems of production or resource use can be analyzed. The major production relationships include: Factor -Product relationship, Factor -Factor relationship and Product-Product relationship

Factor-Product Relations

The Factor-Product Relations deal with the production efficiency of resources. The rate at which the factors are transformed in to products is studied by this relationship. The central goal of this relationship is optimization of production. The relationship is known as input-output relationship by farm management specialists and fertilizer responsive curve by agronomists. Factor-Product relationship guides the producer in making the decision on ‘how much to produce?’ It helps the producer to decide the optimum input level to use and optimum output level to produce. The decision on the optimal levels of input and output is made by using price ratio as the choice indicator. Algebraically, this relationship can be expressed as

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

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

The law of diminishing returns states:

An increase in capital and labor 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

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

The Law originally developed by early economists to describe the relationship between output and a variable input keeping all other inputs constant if increasing amount of one input is added to a production process while all others are constant, additional output will eventually decline the law implies there is a “right” level of variable input to use with the combination of fixed inputs

Limitations:

The law of diminishing returns fails to operate under certain situations. They are called limitations of the law. These limitations under which the law doesn't hold include: improved methods of cultivation, new soils and 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, supervision will become difficult and the costs will go up. The law of diminishing returns, therefore, sets 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. Among them is:

- Excessive dependence on weather
- Limited scope for mechanization
- Soil gets exhausted due to continuous cultivation
- Cultivation extends to inferior lands

Concepts of product curves

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

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.

Marginal product (MP): Additional quantity of output resulting from an additional unit of input used. $MP = \text{Change in total product} / \text{Change in input level } (\Delta Y/\Delta X)$ for discrete change.

Total Physical Product (TPP): It is the Total Product (TP) expressed in terms of physical units like Kgs, quintals, etc. Similarly if AP and MP are expressed in terms of physical units,

they are called Average Physical Product (APP) and Marginal Physical Product (MPP) respectively.

Total Value Product (TVP): Expression of TPP in terms of monetary value is known as Total Value Product. $TVP = TPP * P_y$ or $Y * P_y$

Average Value Product (AVP): The expression of Average Physical Product in money value. $AVP = APP * P_y$

Marginal Value Product (MVP): When MPP is expressed in terms of money value; it is called Marginal Value Product. $MVP = MPP * P_y$ or $(\Delta Y / \Delta X) * P_y$ or $\Delta Y * P_y / \Delta X$

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

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

Relationship between Marginal and Average Product

- If Marginal Product is more than Average Product, Average Product is increasing.
- If Marginal Product is equal with the Average Product, Average Product is Maximum.
- When Marginal Product is less than Average Product, Average Product is decreasing.

Table 1: Relationship between TP, AP and MP

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

Three Regions of Production Function

The production function showing total, average and marginal product can be divided into three regions or stages or zones in such a manner that one can locate the zone of production function in which the production decisions are rational or not. The three stages are shown in the figure below.

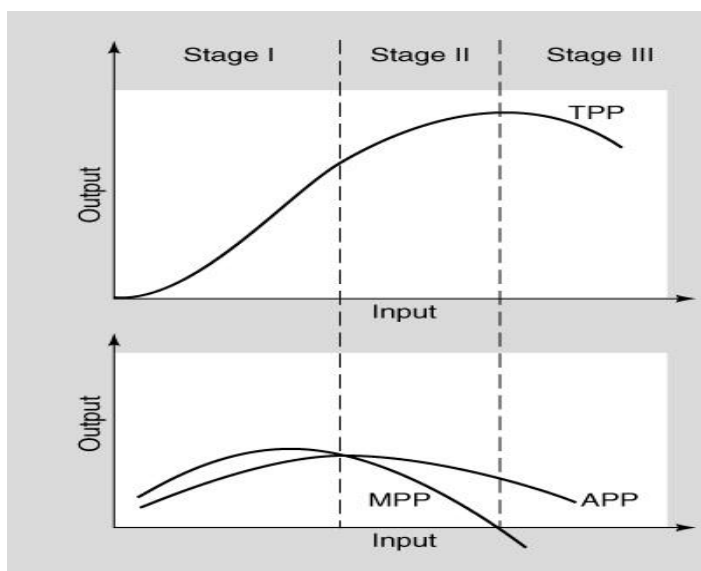


Figure 1: Stages of production

Stage I: In this stage, the average rate at which variable input (X) is transformed into product (Y) increases until it reaches its maximum (i.e., Y/X is at its maximum). This maximum indicates the **end of Stage I**.

The first stage starts from the origin i.e., zero input level. In this zone, Marginal Physical Product is more than Average Physical Product and the Average Physical Product increases throughout 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) and becomes 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 ($MVP > MFC$) and Marginal revenue is more than marginal cost ($MR > MC$). This is irrational or sub-optimal zone of production. And this zone ends at the point where $MPP=APP$ or where APP is Maximum.

For Economic decisions Stage I is 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. Which means 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: The second zone starts from where the technical efficiency of variable resource is maximum i.e., APP is Maximum ($MPP=APP$)

- In this zone Marginal Physical Product is less than Average Physical Product. Therefore, the APP is decreasing throughout this zone.
- Marginal Physical Product is decreasing throughout this zone.
- As the MPP declines, the Total Physical Product increases but at a decreasing rate.
- Elasticity of production is less than one between maximum APP and maximum TPP and becomes zero at the end of this zone.

- In this zone variable resource is more relative to fixed factors.
- The technical efficiency of variable resource is declining as indicated by declining APP.
- The technical efficiency of fixed resource is increasing as reflected by increasing TPP.
- The condition Marginal Value Product is equal to Marginal Factor Cost ($MVP=MFC$) and Marginal Revenue is equal to Marginal Cost ($MR=MC$) exists in this stage
- This is rational zone of production in which the producer should operate to attain his objective of profit maximization.
- This zone ends at the point where Total Physical Product is at maximum or Marginal Physical Product is zero.

Stage II is rational zone of production. The area within the boundaries of this region is 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: This zone starts from where the technical efficiency of fixed resource is maximum (TPP is Maximum). In Stage II:

- 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 (declining APP)
- The technical efficiency of fixed resource is also decreasing (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 zone of production.

Producer should never operate in this zone even if the resources are available at free of cost.

Stage III 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. If farmer operates in this zone, he will incur double loss, that is, reduced production and unnecessary additional cost of inputs.

In summary, for a Factor-Product type production relation, the optimal use of variable factor is the level for which the VMP is equal to the factor price. It is located in stage II. The economic meaning of the optimal solution would mean:

Increasing use of a factor by one unit is profitable if the increase in the total revenue resulting from increased input (= the VMP) is higher than the increase in cost (i.e., the price P_x paid for one unit of the factor). If this condition fulfilled profit is maximized.

4.4 Factor-Factor Relations

This relationship deals with the resource combination and resource substitution. Cost minimization is the goal of factor-factor relationship. Under factor-factor relationship, output is kept constant while inputs are varied in quantity. This relationship guides the producer for a decision on 'how to produce'. Such a relation is explained by the principle of factor substitution or principle of substitution between inputs. Factor-Factor relationship is concerned with the determination of least cost combination of resources. The choice indicators are the physical substitution ratio and price ratio. It is expressed algebraically as:

$Y = f(X_1, X_2, / X_3, X_4... X_n)$, where we consider two variable inputs

In the production process inputs are substitutable. For instance capital can be substituted for labor 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 through choice of inputs and their combinations.

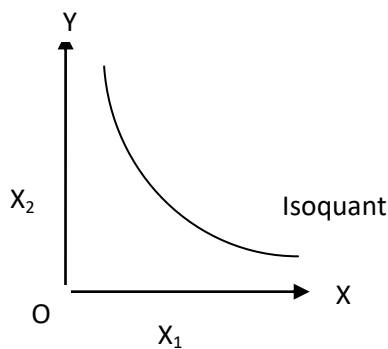
Concept of Isoquants:

The relationship between two factors and output cannot be presented with a two dimensional graph. Three variables can be presented in a three dimensional diagram giving a production surface. An isoquant is a convenient method for compressing three dimensional picture of production into two dimensions. Hence, *isoquant is defined as 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 equal product curves or product indifference curves. Graphical representation of isoquant is given

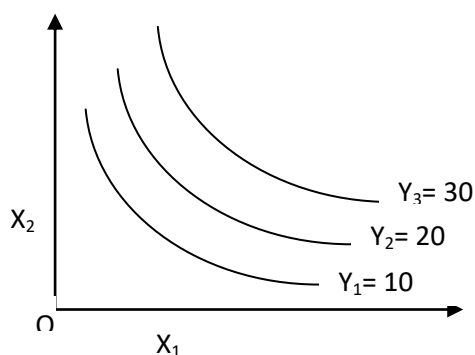
X_1	X_2	Output
3	20	60
4	15	60
6	10	60
10	6	60
15	4	60
20	3	60

curves or below.



Isoquant Map or Isoproduct Contour

If a 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.



Isoquants further from the origin represent higher production level. The Y's in the graph are ordered as $Y_1 < Y_2 < Y_3$

Characteristics of Isoquant

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

Marginal Rate of Technical Substitution (MRTS)

MRTS 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 can be represented as:

$$\text{MRTS } X_1 \text{ for } X_2 = \Delta X_2 / \Delta X_1$$

$$\text{MRTS } X_1 \text{ for } X_2 = \Delta X_1 / \Delta X_2$$

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

MRTS gives the slope of Isoquant. Substitutes indicate 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. Hence MRTS is always less than zero or it is negative.

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.

Fixed Proportion combination of inputs: Under fixed combination, 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.

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.

Decreasing Rate of substitution: Every subsequent increase in the use of one factor in the production process can replace less and less of the 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. Isoquants are convex to the origin when inputs substitute for each other at decreasing rate. Decreasing rate of factor substitution is more common in agricultural production.

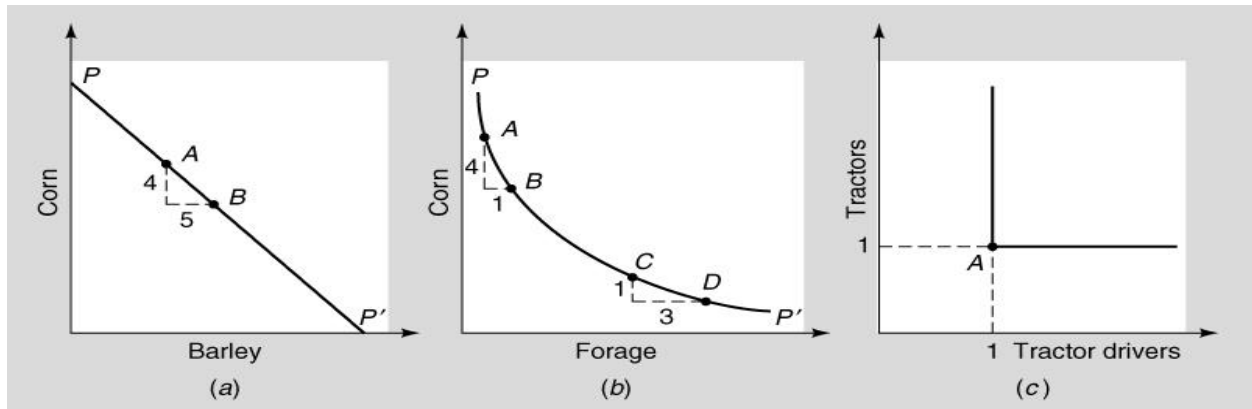


Figure 2: Input Substitution Types

Isocost Line (price line or budget 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. Isocost line is used in the concept of optimal input combination in the production process.

Characteristics of Isocost line:

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

Isocost line is a straight line because input prices do not change with the quantity purchased.

The slope of isocost line determined as 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 cost the least; a cost minimization problem. There are three methods to find out the least cost combination of inputs. These methods are explained below.

Units of X ₁	Units of X ₂	cost of X ₁ (price 3 Birr/unit)	Cost of X ₂ (Price 2 Birr/unit)	Total Cost
10	3	30	6	36
7	5	21	10	31
5	6	15	12	27
3	8	9	16	25
2	12	6	24	30

1. *Simple Arithmetical calculations (presented in Table)*

One possible way to determine the least cost combination is to compute the cost of all possible combinations of inputs and then select the combination with minimum cost. This method is suitable where a limited number of combinations produce a particular level of output. The above table shows five combinations of inputs which can produce a given level of output. The price per unit of X₁ is Birr 3 and of X₂ is Birr 2. The total cost of each combination of inputs is computed and given in the column with Total Cost. Out of five combinations, 3 units of X₁ and 8 units of X₂ is the least cost combination of inputs at a cost of Birr 25 to produce the specified unit of a product.

2. *Algebraic method:*

Compute Marginal Rate of technical substitution

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

MRTS X₁ for X₂ = $\Delta X_2 / \Delta X_1$

MRTS X₂ for X₁ = $\Delta X_1 / \Delta X_2$

Compute Price Ratio (PR)

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

PR = P_{X_1} / P_{X_2} if MRTS X₁X₂ or PR = P_{X_2} / P_{X_1} if MRTS X₂X₁

Least combination occurs at a point where MRTS and PR are equal. i.e.

$\Delta X_2 / \Delta X_1 = P_{X_1} / P_{X_2}$ MRTS X₁X₂

$\Delta X_1 / \Delta X_2 = P_{X_2} / P_{X_1}$ MRTS X₂X₁

The same can be expressed as

$\Delta X_2 * P_{X_2} = P_{X_1} * \Delta X_1$ or $\Delta X_1 * P_{X_1} = \Delta X_2 * P_{X_2}$

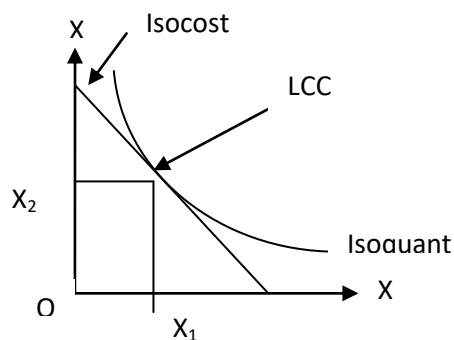
The least cost combination is obtained when Marginal Rate of substitution is equal to Price Ratio. If they cannot be exactly equal because of the choices available in the table, take closer figures without letting the price ratio exceed the substitution ratio.

Units of X_1	Units of X_2	$MRTS_{X_2 X_1}$	$PR = P_{X_2} / P_{X_1}$
10	3	-	0.67
7	5	$(7-10) / (4-3) = 3.00$	0.67
5	6	$(5-7) / (6-5) = 2.00$	0.67
3	8	$(3-5) / (8-6) = 1.00$	0.67
2	12	$(2-3) / (12-8) = 0.25$	0.67

Price of X_1 is Birr 3 per unit, and price of X_2 is Birr 2 per unit

3. Graphical Method:

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



4.5.Product-Product Relations

Product-Product relationship deals with resource allocation among competing enterprises (individual crop production and animal rearing). The goal of Product-Product relationship is profit maximization through optimal combination of enterprises. Under Product-Product relationship, inputs are kept constant while products (outputs) are varied. This relationship guides the producer in deciding on ‘What to produce?’ Product-Product relationship is explained by the principle of product substitution. The relationship is concerned with the determination of optimum combination of production (enterprises). The choice indicators are product substitution ratio and price ratio. Algebraically, product-product relation is expressed as:

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

Production Possibility Curve (PPC)

Production Possibility Curve is a convenient device for depicting two production functions on a single graph. Production Possibility Curve represents all possible combinations of two products that could be produced with a 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 Isoresource Curve or Isofactor 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 namely cotton (Y₁) and Maize (Y₂). Assume all other inputs are fixed. Now the farmer has to decide how much of land input to use for each product. This implies that amount of land that can be used to produce Cotton (Y₁) depends upon the amount of land used to produce Maize (Y₂).

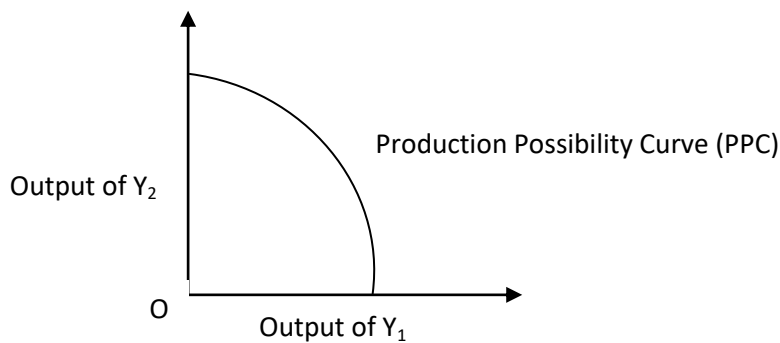
Therefore, $Y_1=f(Y_2)$

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 Y₂ we obtain 60 quintals of Y₂ and do not get any of Y₁. On the other hand, if all the five acres of land are used in the production of Y₁ we can obtain 30 quintals of Y₁ and do not get any of

Y_2 . But these are the two extreme production possibilities. In between the two, there are many other production possibilities. Plotting these two points on a graph, we get the Production Possibility Curve.



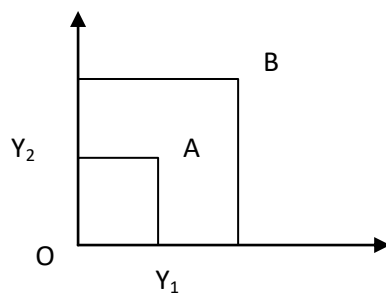
Production Possibility Curve

Types of Product-Product Relationships or Enterprise Relationship

Farm commodities bear several physical relationships to one another. These basic product relationships include:

1) Joint Products: such relationship happen when two products 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. Most farm commodities are joint products.

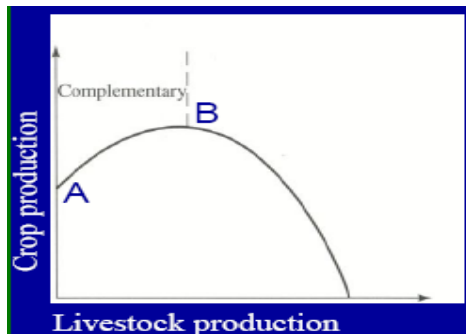
Ex: Wheat and Straw, cattle and manure, beef and hides, mutton and wool etc.



Graphically the quantities of Y_1 and Y_2 that can be produced at different levels of resources will be shown as points AB in the figure.

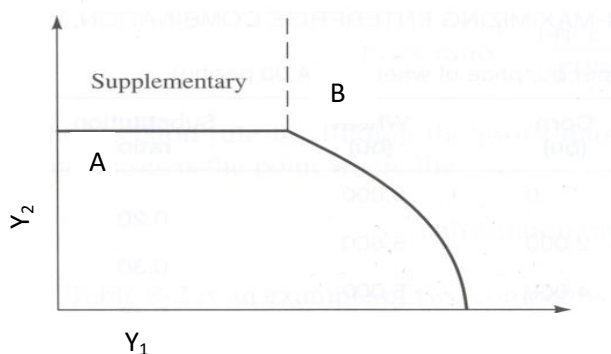
2) Complementary enterprises: Complementarity between two enterprises exists when increasing the production from one enterprise increases the production of the other enterprise. Change in the level of production of one enterprise causes change in the other enterprise in the same direction. That is when increase in output of one product, with resources held constant, also results in an increase in the output of the other product. Temporarily, 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: crops and livestock enterprises.



As shown in the figure, range of complementarities is from point A to point B when increase in the production of one enterprise (crop) followed by increase in the production of the other enterprise (Livestock). After point B the enterprises will become competitive. All complementary relationships should be taken advantage by producing both products up to the point where the products become competitive.

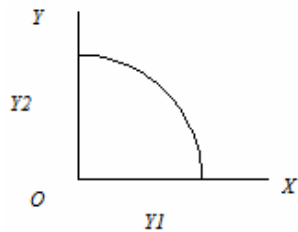
3) Supplementary enterprises: Supplementary exists between enterprises when increase or decrease in the output of one product does not affect the production level of the other product. They do not compete for resources but make use of resources when they are not being utilized by one enterprise. The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



The two products (Y_1 and Y_2) stay supplementary from A to B as shown in the graph. After point B they become competitive enterprises.

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 there

is an increase in output of one product, with resources held constant; production of the other product decreases. 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)



Marginal rate of product substitution (MRPS)

The term marginal rate of product substitution under the product-product relationship has the same meaning as MRTS under the factor-factor relationship. Marginal rate of the product substitution refers to the absolute change in one product associated with a change by one unit of the competing product. The quantity of one product to be sacrificed so as to gain another product by one unit is given by MRPS.

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

MRPS_{Y1} for Y₂ = $\Delta Y_2 / \Delta Y_1$

MRPS_{Y2} for Y₁ = $\Delta Y_1 / \Delta Y_2$

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 and negatively sloped.

Or 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. This relationship can be expressed as

$$\Delta_1 Y_2 / \Delta_1 Y_1 = \Delta_2 Y_2 / \Delta_2 Y_1 = \dots\dots\dots = \Delta_n Y_2 / \Delta_n Y_1$$

Y ₁	Y ₂	ΔY ₁	ΔY ₂	ΔY ₂ /ΔY ₁
16	2	-	-	-
12	4	4	2	0.5
8	6	4	2	0.5
4	8	4	2	0.5

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 products.

$$\Delta_1 Y_2 / \Delta_1 Y_1 < \Delta_2 Y_2 / \Delta_2 Y_1 < \dots\dots\dots < \Delta_n Y_2 / \Delta_n Y_1$$

Y ₁	Y ₂	ΔY ₁	ΔY ₂	ΔY ₂ /ΔY ₁
1	14	-	-	-
2	11	1	3	3
3	7	1	4	4
4	2	1	5	5

3) Decreasing rate of Product Substitution:

Each unit increase in the output of one product is accompanied by 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. This relationship is algebraically expressed as

$$\Delta_1 Y_2 / \Delta_1 Y_1 > \Delta_2 Y_2 / \Delta_2 Y_1 > \dots > \Delta_n Y_2 / \Delta_n Y_1$$

Y ₁	Y ₂	ΔY ₁	ΔY ₂	ΔY ₂ /ΔY ₁
1	10	-	-	-
2	6	1	4	4
3	3	1	3	3
4	1	1	2	2

IsoRevenue Line

Isorevenue line represents all possible combination of two products which would yield an equal (same) revenue or income. Let R is the revenue from two products Y₁ and Y₂ and the prices for both products is given as P_{y1} and P_{y2} respectively. The Isorevenue equation will be given as:

$$R = Y_1 * P_{y1} + Y_2 * P_{y2}, \text{ the line is linear as long as prices for both products do not change}$$

Characteristics:

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

As the total revenue increases, the isorevenue line moves away from the origin

The slope indicates ratio of product (output) prices. As long as product prices remain 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 (Economic decision):

The Economic optimum combination of the two products can be determined through three different ways:

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 product / Number of units of added product

MRPS_{Y1 for Y2} = ΔY₂/ΔY₁

MRPS_{Y2 for Y1} = ΔY₁/ΔY₂

b) Workout price ratio (PR)

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

$PR = P_{Y_1}/P_{Y_2}$ if it is $MRPS_{Y_1Y_2}$

$PR = P_{Y_2}/P_{Y_1}$ if it is $MRPS_{Y_2Y_1}$

c) Find the combination at a point where substitution ration (MRPS) is equal to price ratio (PR). This gives us the Optimum combination of enterprises.

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

$$\Delta Y_2/\Delta Y_1 = P_{Y_1}/P_{Y_2} \quad \text{or} \quad \Delta Y_1/\Delta Y_2 = P_{Y_2}/P_{Y_1}$$

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

2) Graphic Method:

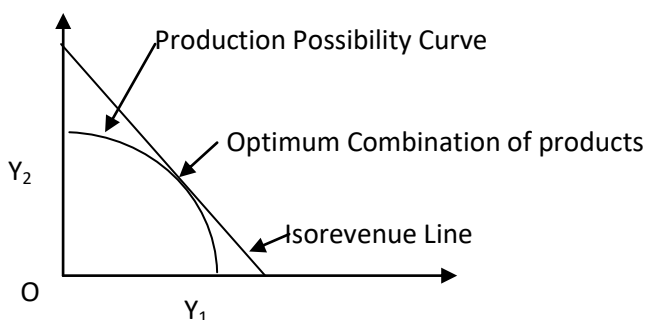
In this method follow the procedure given below to find the optimal product combination.

Draw production possibility curve and isorevenue line on one graph.

Slope of production possibility curve indicates MRPS and the slope of isorevenue line indicate price ratio of products.

The point of optimum combination of products is at a point where the isorevenue line is tangent to the production possibility curve.

At the tangency point, slope of the isorevenue line and the slope of the production possibility curve will be the same. In other words, the $MRPS=PR$ which gives the optimum combination.



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. Accordingly, the optimum combination includes 3 units of Y_1 and 7 units of Y_2 where the revenue at this combination is the maximum as indicated in the table.

Y ₁	Y ₂	Revenue from Y ₁ (P _{y1} =50)	Revenue from Y ₂ (P _{y2} =80)	Total Revenue
8	2	400	160	560
5	3	250	240	490
6	4	300	320	620
4	5	200	400	600
3	7	150	560	710

Table 2: 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
Answers the question ‘How much to produce?’	Answers the question ‘How to produce?’	Answers the question ‘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 determination of optimum input to use and optimum output to produce	Concerned with the determination of Least cost combination of resources	Helps in the determination of optimum combination of products
Price ratios are choice indicator	Substitution ratio and Price 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
$Y=f(X_1 X_2, X_3 \dots\dots X_n)$	$Y = f(X_1 X_2 / X_3, X_4 \dots X_n)$	$Y_1=f(Y_2, Y_3, \dots\dots Y_n)$

Course unit Activity

Dear students

Please read the course material and do the following activities accordingly

1. Complete the following table

Units of labour	Total product	Marginal product	Average product
1	50		
2	90		
3	120		
4	140		
5	150		
6	150		
7	140		
8	120		

2. Please do it by indicating necessarily steps

Units of capital	Total product	Average product	Marginal product
1			20
2			16
3			12
4			8
5			4

3. Identify the different output levels which mark the three stages of production in the following data:

Units of variable input	Total product(TP) (units)
0	-
1	100
2	120
3	360
4	520
5	650
6	750
7	840
8	880
9	880
10	830
11	770

4. Calculate MRTS for each combination given in the following table:

Combination	Units of capital (K)	Units of labour(L)
A	1	15
B	2	10
C	3	6
D	4	3
E	5	1

NB. Please do it alone!

5. Section five

5.1 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 farm business.

5.1.1 What is farm planning?

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

Farm Planning means the preparation of an operational program for a farm which will ensure the conservation of land and other resources. It's important for the efficient use of production factors thereby increase the net income and farmer satisfaction. Farm plans are particularly required when there are limiting factors such as land, labour and capital. This necessitates efforts to maximize returns to the limiting factors. A farmer makes plans before starting production. For example, in crop production, the farmer decides on the crop types (such as maize, yam, beans, etc.) and resources to put into production (such as farmland, seed, fertilizer, labor for farm operations, etc.). The result of crop production is the output, while the resources are the production inputs.

Production inputs and output are measured in different units-hectares, person-days, kilograms, liters, and so on. Aggregation of the components is possible by using a common unit of measurement. The unit of measurement is usually monetary (currency unit). Thus, the values (quality and quantity) of inputs and output are expressed in monetary terms in a budget. The monetary symbol used can for instance be ETB (Ethiopian Birr) or USD (US – dollar).

Farm planning enables the farmer to achieve his objectives (e.g. 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 farm a viable unit. Farm plan is a programme of total farm activity of a farmer drawn up in advance.

It should show the enterprises to be taken up on the farm; the practices to be followed in their production, use of labor and other resources , investments to be made and similar other details.

5.1.2. Objectives of farm planning

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

- a) It helps him examine carefully his existing resource situation and past experiences as a basis for deciding which of the new alternative enterprises and methods fit his situation in the best way.
- b) It helps him identify the various supply needs for the existing and improved plans.
- c) It helps him find out the credit needs, if any, of the new plan.
- d) It gives an idea of the expected income after repayment of loans, meeting out the expenditure on production, marketing, consumption, etc.
- e) A properly thought of a farm plan might provide cash incomes at points of time when they may be most needed at the farm. A farm plan is a programme of total farm activities of a farmer drawn out in advance. An optimum farm plan will satisfy all the resource constraints at the farm level and yield the maximum profit.

5.1.3 Features of a good farm plan

A good farm plan generally should have the following characteristics:

- a) An element of flexibility in a farm plan is essential to account for changes in the environment around the farm.
- b) A farm plan should maximize the resource use efficiency at the farm.
- c) It should provide for the attainment of the objectives of profit maximization through optimum resource use and balanced combination of farm enterprises.
- d) Risk and uncertainty can be accounted for in a good farm plan.
- e) The plan helps in timely acquisition and repayment of farm credit.

5.1.4 Levels of farm planning

Farm planning can be done at two levels: simple farm planning and whole/complete farm planning. They are explained below.

Simple farm planning: It is procedure 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.

Complete or whole farm planning: This is the planning for the whole farm. A whole-farm plan is an outline or summary of the type and volume of production to be carried out on the entire farm and the resources needed to do it. This planning is adopted when major changes are contemplated in the existing organization of farm business. When the expected costs and returns for each part of the plan are organized into a detailed projection, the result is a whole-farm budget. Whole-farm planning and budgeting are used to assess the combined profitability of all enterprises in the farming operation.

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

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

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

c) Control: This provides for observing the results of the implemented plan to see if the specified goals and objectives are being met. Many things can cause a plan to go “off its track”. Price and other changes, which occur after the implementation of the plan, can cause the actual results to deviate from the expected. Control requires a system for making regular checks on the plan and monitoring progress and results as measured against the established goals. The dashed line in the chart represents the continuous flow of information from the control function back to planning, an important part of the total system. Without some feedback procedure, the information obtained by the control system is of no use in making corrections in the existing plan or improving future plans. This feedback sets up a continuous cycle of planning, implementation, monitoring and recording progress, followed by a re-

evaluation of the plan and the implementation procedures using the new information obtained through the control function.

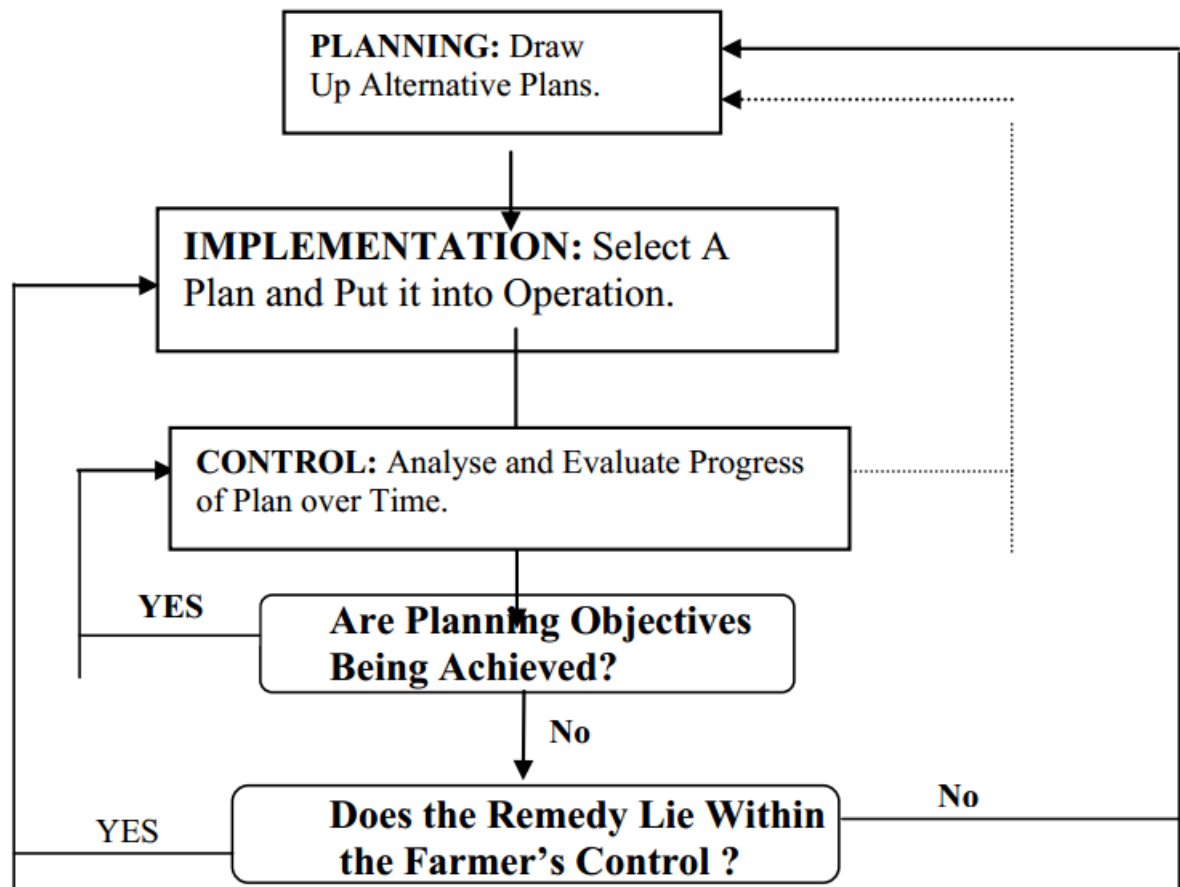


Figure1. *Steps in Farm Planning*

5.2 Farm budgeting

4.2.1 What is farm budgeting?

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

Farm Budgeting and Advantages

Farm budgeting involves considering the resources to be used, the choice of enterprises to be pursued and calculation of expected receipts, expenditures and net farm income. Some of the several advantages of budgeting are:

- Budgeting assists the farm manager to select factors of production more wisely. For instance, once some fixed resources are invested in the farm business budgeting can be used to test and compare returns from the whole farm and other added resources.
- As a planning tool, budgeting lets the farm manager to think more accurately, plan more carefully and completely. Through the process of budgeting, the farm manager refines his ideas and is better able to make more accurate decisions.
- Budgeting is money saving activity because it is cheaper to make mistake on paper than in practice.
- Budgeting provides an excellent learning device on how to organize and reorganize farms.
- Lending agencies use budgeting process as a basis for appraising the farm business of their clients.
- Budgeting helps a farm manager to determine when to borrow money and how much to borrow. It can also help him in setting up repayment schedules.
- Budgeting makes early warning possible where one can discover certain items, and therefore costs, that could easily be dropped.

Budgeting Pre-requisites/Steps in Budgeting

Information needed to prepare a farm budget, whether complete or partial must follow the following pattern

- Stating objectives and listing of all the resources available to the farm. It is essential to list all the resources available to the farm business - land, labour and capital. Making changes which require more resources than the farmer can acquire could be disastrous. Hence, objectives of making the farm plan or planned change must be carefully laid down, properly understood and strictly operationalized within the resources listed.
- Estimate crop land size and livestock number. This helps to sketch map of available land with crops on farm. In the case of crop enterprises the proposed changes could be sketched out in other map for ease of reference.
- Estimating physical inputs and outputs. The farm manager needs to produce a list of available labour in man-days; the quantity of hired labour, permanent labour and family labour available should be specified by periods preferably on monthly basis. The available capital including farmer's savings and any amount borrowed need to be clearly indicated. Finally the farmer or farm manager should examine his ability in effecting any anticipated change (partial or whole farm).

- Estimating factors and product prices- Current market prices or a few years' moving average could be used as a proxy for factor and product prices.
- Decide which plan is possible- from the whole range of alternative plans available to the farm manager he can reject outright those plans that do not interest him or those that he cannot manage properly.
- Budget the Possible Alternative - The possible alternative plans are compared on the basis of the gross margin per unit of the most limiting resources. For example,if labour is the most limiting resource; the plan with the highest gross margin per man-day should be selected.
- Implement the Best Plan- Once the farmer selects the best plan; it must be put into operation. Farm owners should be ready to accept responsibility for the outcome of its implementation.

Budget, an outcome of budgeting procedure, is a formal quantitative expression of plans on production inputs and output. Budgets indicate the type, quality, and quantity of production resources or inputs needed, and the type, quality, and quantity of output or product obtained. Three types of budgets are used in agriculture: whole-farm budget, enterprise budget and partial budget.

5.2.2 Types of budgeting and their analysis

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

- A) Partial Budgeting. C) Cash flow Budgeting.
- B) Enterprise Budgeting. D) Complete Budgeting.

A) Partial Budgeting.

Partial budget- A partial budget is prepared to show the effect of change(s) in farm operations. For example, farmers know that fertilizer application will likely increase maize yield, and thus the gross income. The use of fertilizer also results in additional costs. To decide whether to use fertilizer for maize production or not requires a partial budget analysis. A partial budget could be prepared to ascertain the effect on net benefit of the following possible changes:

- Substituting one enterprise for another without any change in the entire farmland area, for example, substituting 1 ha of soybean for 1 ha of maize
- Changing to different levels of a single technology, for example, estimating the effect on net benefit of changing from one level of N-fertilizer application to another in maize production

- Changing to different technology(ies), for example, changing from hand weeding to herbicide use for weed control

Developing a partial budget for on-farm maize research involves collecting, organizing, and analyzing experimental data in order to quantify the income, costs, and benefits of various alternative maize technologies.

Table: A partial budget for maize production under different weed control methods

Nr	Item Description	Weed control method			
		No weeding (1)	Hand weeding (2)	Boom spraying (3)	Knapsack spraying (4)
	Gross farm gate benefits				
1	Average yield (kg/ha)	1,266	3,986	3,797	2,833
2	Adjusted yield (kg/ha) (1 x 0.9)	1,139	3,587	3,417	2,550
3	Farm gate price (Birr/kg)	0.75	0.75	0.75	0.75
4	Gross farm gate benefits (Birr/ha) (2 x 3)	854	2,690	2,563	1,913
	Variable input costs (Birr/ha)				
5	Weed control				
	– Labor	0	360	10	60
	– Machinery	0	0	50	25
	– Herbicides	0	0	160	160
6	Harvesting	42	70	70	70
7	Shelling	20	30	30	25
8	Total variable input costs (Birr/ha) ($\Sigma 5...7$)	62	460	320	340
	Net benefit				
9	Net benefit (Birr/ha) (4 – 8)	792	2,230	2,243	1,573
10	Changes in net benefits from Treatment 1 to Treatment 2, 3, or 4* (Birr/ha)		1,438	1,451	781
11	Change in total variable input costs from Treatment 1 to Treatment 2, 3 or 4* (Birr/ha)		398	258	278

	Marginal rate of return				
12	Marginal rate (%) of return (100 x 10/11)		361	562	281

* Change in net benefits between Treatments 1 and 2 is $2,230 - 792 = 1,438$

Change in net benefits between Treatments 1 and 3 is $2,243 - 792 = 1,451$

Change in net benefits between Treatments 1 and 4 is $1,573 - 792 = 781$

* Changes in the total variable costs calculated in similar ways

A partial budget, like an enterprise budget, is based on a unit (for example, one ha maize farm) but it is different from an enterprise budget in the type of costs used. An enterprise budget uses total costs (variable input costs plus fixed input costs) while only variable input costs are used in a partial budget. In a partial budget, income is the gross farm gate benefit. The net benefit is the difference between the gross farm gate benefit and total variable input costs. Table gives an example of partial budget. The partial budget in this case shows different levels of the same single technology. The objective of a partial budget in maize production is to recommend technology that is agronomically different, economically superior, and socially acceptable to farmers.

B) Enterprise Budgeting.

Enterprise budget- An enterprise is a single crop or livestock type produced on a farm. An enterprise budget lists all income and costs of a specific enterprise to provide an estimate of its profit. Each enterprise budget is developed on a single common unit, such as hectares for crops or head for livestock. An enterprise budget allows comparison of profitability among different enterprises on the same farm.

Enterprise budgets, like whole-farm budgets, have three parts: income, costs, and profit. Table 6 gives an example of enterprise budget. The enterprise budget in Table 6 presents different levels of the same single technology.

An enterprise budget is different from a whole-farm budget in aspects:

- the number of enterprises considered (only one in an enterprise budget; in a whole-farm budget, all enterprises in the farm are included)
- the size of enterprises (a single unit for an enterprise budget, the entire farm for a whole-farm budget)

Table 6: An enterprise budget for the production of an improved open-pollinated maize variety at different N-fertilizer application levels

N r		N-fertilizer level (kg N/ha)		
		0 (Treatment 1)	100(Treatment 2)	200 (Treatment 3)
	Gross income			
1	Average yield (kg/ha)	2,592	3,983	4,331
2	Adjusted yield (kg/ha) (1 x 0.9)	2,333	3,585	3,898
3	Price (Birr/kg)	2.5	2.5	2.5
4	Sale revenue (Birr/ha (2 x 3))	5832	8961.75	9744.75
	Input costs (Birr/ha)			
5	Land preparation	350	350	350
6	Planting			
	Materials (maize seed and seed dressing)	40	40	40
	Labor	20	20	20
7	Weed control (herbicides and application costs)	400	400	400
8	Thinning	25	25	25
9	N-fertilizer	0	150	300
10	Other fertilizers	135	135	135
11	Miscellaneous	200	200	200
12	Harvesting (labor)	70	85	90
13	Shelling	30	32	35
14	Drying	60	64	67
15	Cost of capital	211	237	261
16	Depreciation costs(Birr/ha)	75	75	75
17	Total variable input costs (Birr/ha)(Σ5...15)	1,541	1,738	1,923
18	Total fixed costs (Birr/ha) (16)	75	75	75
19	Total input costs (Birr/ha) (17 + 18)	1,616	1,813	1,998
	Net profit			
20	Net profit (Birr/ha) (4 – 19)	4,216	7,149	7,747

C) Cash flow Budgeting.

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

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

Here, two time periods are considered. In the time period I, there is Birr 3, 000 cash inflow and Birr 14, 000 cash outflow, leaving projected cash balance of – Birr 11, 000. This would require a borrowing of Birr 12, 000 to permit Birr1000 minimum ending cash balance. The total cash outflow in the period II is Birr18, 000 which leaves projected cash balance of Birr16, 000 and it permits paying off the debt incurred in period I, estimated at Birr12, 720 when interest is included. The final result is an estimated Birr3, 280 cash balance at the end of second period. The primary use of a cash flow budget is to project the timing and amount of new borrowing; the business will need during the year and the timing and amount of loan repayment

D) Complete/ Whole-farm Budgeting.

Whole-farm budget- A whole-farm budget is a quantitative expression of the total farm plan summarizing the income, costs, and profit (Table 7). Income is what a farmer realizes from

farming activities, costs are what the farmer puts into production, and profit is the difference between income and costs. In a whole-farm budget, the unit of analysis is the entire farm. A whole-farm budget may consist of several enterprises. Example for whole-farm budget is given in the table below.

Table 7: A whole-farm budget showing projected income, input costs, and profits

Nr	Income	Amount (Birr)	Nr	Variable input costs (cont...)	Amount (Birr)
1	Maize	56,000	15	Custom machine hire	9,350
2	Cassava	48,000	16	Miscellaneous	3,560
3	Beans	13,600	17	Total variable input cost ($\Sigma 7...16$)	87,060
4	Yam	32,000	18	Income above variable input cost (6 – 17)	102,540
5	Poultry	40,000		Fixed costs	
6	Total income ($\Sigma 1...5$)	189,600	19	Land charge	2,000
	Variable input costs		20	Insurance	4,850
7	Fertilizers	12,900	21	Interest on loans	24,000
8	Seeds and cuttings	3,000	22	Machinery depreciation	9,200
9	Chemicals	8,900	23	Building depreciation	3,600
10	Fuel, oil, and grease	4,000	24	Total fixed costs ($\Sigma 19...23$)	43,650
11	Machinery repairs	3,650		Total costs	
12	Feed	2,600	25	Total input costs (17 + 24)	130,710
13	Point-of-lay chickens	35,000		Profit	
14	Labor	4,100	26	Profit (6 – 25)	58,890

Section activity

1. What is the importance of farm planning to farmer?
2. What are the merits of each type of farm planning to the farmer?
3. Please list and discuss tools of planning

6. Section six

6.1. Production cost

Pre-test question

- What is cost?
- What are the components of costs in agriculture?

Meaning of farm costs

Cost concepts are of profound importance in farm business since they enable us to make choices among present alternative actions. For each possible present action, the measure of the present and future forsaken opportunities is the "cost." The sacrifice is made inevitable when the present action is taken and in this sense, the present action involves present cost.

We can define cost in strict business connotations as the *change in equity* that is caused by the performance of some specified operations. In everyday usage, farm costs comprise expenditures in money and imputed terms, which a farm operator incurs in the operation of his business. This simplistic definition often masks a lot of complexities that are found in allocating costs in farm business. These complexities are such that various measures of costs are employed in clearly determining net returns in practice, as opposed to the simplified notions in production theory.

Cost Principles

Most of the Producers give considerable importance to the cost of production while keeping production decision. When we speak of cost of producing a commodity, we generally refer to the expenses incurred in producing a unit of a product in a particular 2 time period, without specifying the amount and the time period, any reference to cost will be meaningless. Cost consideration enters into almost every day in farm organization and operations. To get a clear picture of cost concepts that is appropriate to farm management decisions, the cost problems is divided into three parts: (i) Cost output relation. (ii) Cost price relation (iii) Product cost in joint farm operation and joint product.

6.3. Allocation of costs

Production processes do not always yield only one product or output. As a matter of fact, many farm enterprises give joint products. Joint products are interdependent in supply, since more of one product generally involves more of the other. In fact, a higher price of one of the products of joint outputs will, by inducing a larger output, also lead to an increased output of

the other commodity. Thus, the supply of a good is dependent not only on its own price, but that of other goods -- especially of joint product goods. In fact, the ratio in which joint products are produced is variable, justifying why they also are substitutable at the same time as they are joint.

One problem which plagues farm producers is how one should allocate the costs of the common resources employed in producing each of the joint products. For example, hides and meat are produced from one steer fed on a ration of mixed feeds. The problematic question is: what portion of the cost of feed is the cost of the hide and what portion is the cost of beef? This boils down to the relevant and specific question: Can a "common" cost be allocated among joint products?

The valid answer to this specific question will depend on how we treat each product. In other words, which of the two joint products is treated as a residual or by-product helps us to decide the different allocation of costs. Thus, by calling one of the two products the "basic" product, and the other, the "by-product", we can implicitly as well as explicitly assign the "common costs" between the two goods. This, it must be stressed, is merely an arbitrary allocation which depends solely on which product one calls the basic product.

Another problem which plagues farm operators is how to assess the costs of unpaid inputs. The farm inputs that are conventionally referred to as unpaid or non-cash inputs are operator and family labor services plus farmer-owned or farmer-supplied inputs. Although the measurement in physical terms per se of each of these inputs presents some problems, the role of judgment becomes magnified when we have to weigh these items by constant prices in order to make aggregation possible. The fact that these inputs are not bought and sold as are most other farm inputs, complicates the determination of what prices we should consider most appropriate to use as weights.

Three techniques are usually adopted in deriving prices for unpaid labor and capital inputs in farm business. The first technique is that of deducting from gross income all expenses other than unpaid capital and labor and to call the residual the value of the composite unpaid factors. The second technique is to assign to unpaid labor and capital inputs the prices paid for the labor and capital that are purchased, and used in the way most similar to that of the unpaid inputs. In other words, we use the per unit price of hired farm labor and borrowed farm capital to estimate the prices of the unpaid inputs, which means using hired farm wage rates and interest rates on borrowed capital as price weights for the unpaid labor and capital respectively. The third technique is that of using a combination of the first and second techniques. This implies deducting from the composite residual either labor or capital costs

calculated at the rate which uses the second technique, the rest of the residual is then associated with either unpaid labor or unpaid capital, as the case may be.

Agricultural cost functions

Short Run: Short run is defined as a period of time during which production can be varied only by changing the quantities of variable factors and not of fixed factors. Land, factory buildings, heavy capital equipment, and services of high-category management are some of the

factors that cannot be varied in a short period. That is why they are called fixed factors. On the other hand, there are some factor inputs that can be varied as and when required – for instance, power, fuel, labour, raw materials, etc. They are called variable factors. Accordingly, in short-run production, we have two types of costs - fixed costs and variable costs. Long run is defined as a period which is long enough for the inputs of all factors of production to be varied. In this period, no factor is fixed, and all are variable factors. Accordingly, in the long run, all costs are variable costs.

Total Costs in the Short Run

There are three concepts concerning total cost in the short period: Total Fixed Cost, Total Variable Cost, and Total Cost. Fixed cost is that cost which is incurred for fixed factors. Fixed costs consist of salary of the permanent staff, interest on borrowed capital, rent of the factory buildings, depreciation of machinery, expenses for maintenance of buildings, property tax and license fees etc. Cost functions represent the mathematical presentation of the relationships between total cost of production and the output produced. The costs of production might also be defined not in terms of the use of the input, but in terms of the output. To do this, some basic terms need to be explained.

Variable costs (VC) are the costs of production that vary with the level of output produced by the farmer. For example, in the production of corn, with the time period being a single production season, variable costs might be thought of as the costs associated with the purchase of the variable inputs used to produce the corn. Examples of variable costs include the costs associated with the purchase of inputs such as seed, fertilizer, herbicides, insecticides, and so on. In the case of livestock production within a single production season, a major variable cost item is feed. Variable cost is cost which is incurred for variable factor. The main types of variable cost are expenditures incurred for raw materials, wages and salaries paid to casual workers, operating expenses like electricity, and taxes such as excise duties, which depend upon the output produced.

Fixed costs (FC) are the costs that must be incurred by the farmer whether or not production takes place. Examples of fixed-cost items include payments for land purchases, and depreciation on farm machinery, buildings, and equipment.

The categorization of a cost item as fixed or variable is often not entirely clear. The fertilizer and seed a farmer uses can only be treated as a variable cost item prior to the time in which it is placed in the ground. Once the item has been used, it is sometimes called a sunk, or unrecoverable, cost, in that a farmer cannot decide to sell seed and fertilizers already used and recover the purchase price.

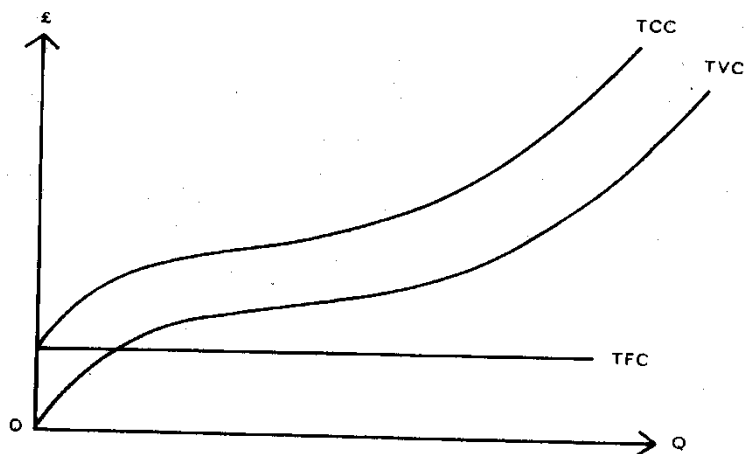


Figure 8.2. Generalized cost function.

Table 1: Behavior of average cost

Output (Units)	TFC (Birr)	TVC (Birr)	TC (Birr)	AFC (Birr)	AVC (Birr)	ATC (Birr)	MC (Birr) = (TC/Q)
(1)	(2)	(3)	(4) (2 + 3)	(5) (2÷1)	(6) (3÷1)	(7) (4÷1) or (5+6)	(8) (TG - TG ₋₁)
0	60	0	60	—	—	—	—
1	60	40	100	60	40	100	40
2	60	76	136	30	38	68	36
3	60	102	162	20	34	54	26
4	60	132	192	15	33	48	30
5	60	170	230	12	34	46	38
6	60	222	282	10	37	47	52

Although depreciation on farm machinery is normally treated as a fixed cost, given sufficient time, the farmer does have the option of selling the machinery so that the depreciation would no longer be incurred. Payments for the purchase of land would not be made if the farmer elected to sell the land. The categorization of farm labor is very difficult. A farm laborer on

an annual salary might be treated as a fixed cost which the farmer incurs whether or not production takes place. But if the laborer is laid off, the cost is no longer fixed. Temporary workers hired on an hourly basis might be more easily categorized as a variable cost.

Over a very short period of time, perhaps during a few weeks within a single production season, a farmer might not be able to make any adjustment in the amounts of any of the inputs being used. For this length of time, all costs could be treated as fixed. Thus the categorization of each input as a fixed- or variable-cost item cannot be made without explicit reference to the particular period involved. A distinction between fixed and variable costs has thus been made on the basis of the period involved, with the proportion of fixed to variable costs increasing as the length of time is shortened, and declining as the length of time increases.

Some economists define the long run as a period of time of sufficient length such that the size of plant (in the case of farming, the farm) can be altered. Production takes place on a short-run average cost curve (*SRAC*) that is U shaped, with the manager equating marginal revenue (the price of the output in the purely competitive model) with short-run marginal cost (*SRMC*). There exists a series of short-run marginal and average cost curves corresponding to the size of the particular plant (farm). Given sufficient time, the size of the plant can be altered. Farmers can buy and sell land, machinery, and equipment. Long-run average cost (*LRAC*) can be derived by drawing an envelope curve which comes tangent to each short run average cost curve (Figure 6.2).

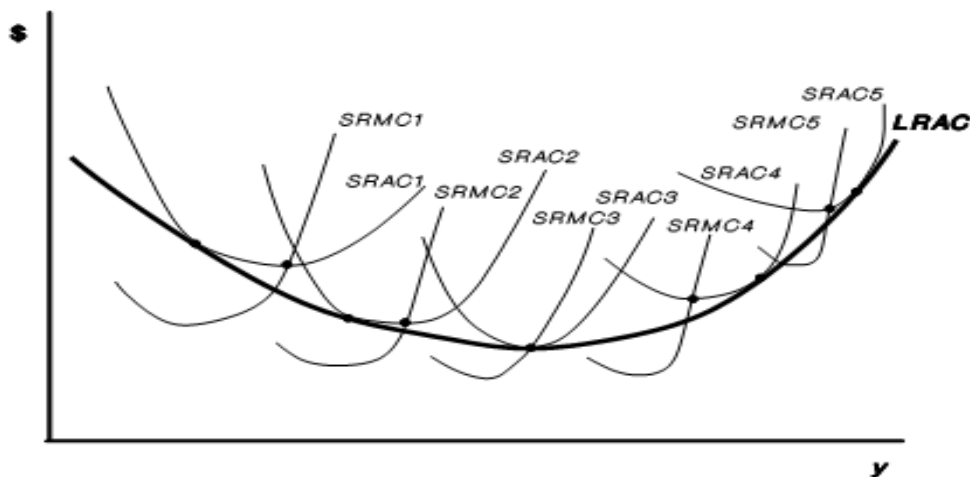


Figure 6.2 Short and Long-Run Average and Marginal Cost with Envelope Long-Run Average Cost

Variable costs are normally expressed per unit of output(y) rather than per unit of input(x). This is because there is usually more than one variable cost item involved in the production of agricultural commodities. A general expression for a variable cost function is:

$$VC=g(y)$$

Since fixed costs do not vary with output, fixed costs are equal to some constant money value k ; that is: $FC=k$

Total costs (TC) are the sum of fixed plus variable costs.

$$TC=VC + FC \text{ or,}$$

$$TC= g(y) + k$$

Average variable cost (AVC) is the variable cost per unit of output

$$AVC = VC/y = g(y)/y$$

Average fixed cost is equal to fixed cost per unit of output

$$AFC = FC/y = k/y$$

There are two ways to obtain average cost (AC), sometimes also called average total cost (ATC). One way is to divide total cost (TC) by output (y)

$$AC=ATC=TC/y$$

Another way is to sum average variable cost (AVC) and average fixed cost (AFC)

$$AC=ATC=AVC + AFC$$

$$AC=ATC=VC/y +FC/y$$

Marginal cost is defined as the change in total cost, or total variable cost, resulting from an incremental change in output.

$$MC = \Delta TC/\Delta y = \Delta VC/\Delta y$$

Since the value for fixed costs (FC) is a constant k , MC will be the same irrespective of whether it is based on total costs or total variable cost.

Generally,

Cost Principle $TC = VC+ FC$ Net Revenue = $TR -TC$ (A) In the short run: Gross revenue (GR) must cover the VC . Maximum net revenue is obtained when $MC = MR$. If $GR < TC$ but $> VC$, guiding principle should be to keep increasing production as long as $MR > MC$. In the short run, $MC = MR$ point may be at a level of input use that may involve a loss instead of profit. Yet at this point loss will be minimized. This situation of operating the farms when MR is $> AVC$ but $< ATC$ is common in agriculture. This explains why farmers keep on doing farming even when they run into losses. (B) In the long Run: GR should be $> VC + FC=TC$. For taking production decision in such a situation, one should go on using resources as long

as added returns remain greater than added total costs. Here, the object is to maximize profits instead of minimizing the losses

Practical Work

1 Complete the following table:

Output (Units)	Total Cost (birr)	TFC (birr)	TVC (birr)	MC (birr)
0	20			
1	38			
2	50			

2. Read about the following cost categories

- A. Private cost
- B. Social cost
- C. Explicit cost
- D. Implicit cost
- E. Economic cost
- F. Opportunity cost

3. The following table shows the total cost of production of a firm at different levels of output. Find out the average variable cost and the marginal cost at each level of output

Output(units)	0	1	2	3
Total cost(birr)	60	100	130	150

4. The following table shows the marginal cost at different levels of output by a firm. Its total fixed costs are Birr 90.

Find its average total cost and average variable cost at each level of output:

Output(units)	1	2	3
Marginal cost(birr)	30	20	22

NB. Do it alone!

7. Risk and Uncertainty in Agriculture

Pre-test questions

- What is risk and uncertainty mean?
- Do you think there is similarity between the two terms?
- Can you mention the impact of risk in farming activity?

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 managers are the ones with the ability to make the best possible decisions, and courage to make them when surrounded by risk and uncertainty.

Biological nature of farm enterprise entails some uncertainties in their production and prices in addition to uncertainties related to availability of inputs. Some of them are measurable in their parameters of probability, yet others are more or less random phenomena that cannot be estimated with any acceptable degree of accuracy. The first category uncertainties lead to the business risks that can be, to a considerable extent, provided for either through adjustments in the production programs and resource use planning or through hedging, forward contracts, insurances, etc. The latter category cannot be treated as calculable risks and are not amenable to programs of production or resource use adjustments. How these risks and uncertainties are accounted for in the production programs of the farmers is the central objective of this chapter. Discussion here center around i) how do the farmers in their normative production programs account for estimable uncertainties (risks) of price fluctuations and yield (production) variability of farm products, and ii) how do they provide for uncertainties on the availability of factor inputs.

Definitions

Risk is a situation in which all possible outcomes (results) of an activity are not certain (not known), but the probabilities of alternative outcomes (results) are known or can be estimated. Example, if a farmer know that his maize crop is likely to fail in one of the four years of consecutive production period by 25% then this is a risk because even if he doesn't know the exact year he is expecting failure in one the four years of production period.

Uncertainty is a situation where all possible outcomes and the probability of the outcomes are unknown or neither the outcome nor the probability are known . Uncertainty is not insurable. It is a situation where an action has got a set of possible outcomes the probability of which is completely unknown. For example, no one can assign probability to how many times he will fall sick within a year. Farmer normally calculates his labor requirements on the ground that his workers will be healthy throughout the year and that each labor will supply at least eight working hours per day. Similarly, no one can precisely predict when he is going to die. Farm manager may project his activity for the whole year and he may not reach the end of that year before he dies. Any situation where one cannot predict what can happen is normally regarded as uncertain situation.

Types of risk and uncertainty in agriculture

The more common sources of risk can be summarized into the general types as: production risk, marketing risk, financial risk and technological risk

Production or yield risk: refers to the unpredictable impact of climate, crop and livestock diseases and pests, and other natural and manmade calamities on outcome (output).

Price or marketing risk: are risk associated with the variability of output of price and its effect on the farm income. Commodity prices vary from year to year and may have substantial seasonal variation within a year.

Financial risk: a risk incurred when money is borrowed to finance the operation of the business. That is, any time money is borrowed there is some chance that future income will not be sufficient to repay the debt without using equity capital.

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.

Probability and Expectations

To make decision in a risky world, a manager needs to understand how to form expected value, how to use probability (chances of occurrence), and how to analyze the variability associated with the potential outcome.

Forming expected values: The major methods used to form expected values are:

- Average (simple and weighted average)
- Most likely method
- Mathematical expectation

Average (simple average)

Consider the following price over years for maize

Table 8: Annual maize price variation

Year	Average of annual price
4 years ago	2.50
3 years ago	3.05
2 years ago	2.00
Last year	4.50
Summation	12.05
Average (expected value) = $12.05/4 = 3.01$	

Weighted average

This method usually weights the more recent values heavier than the older using some predetermined weighing system on the basis of the decision maker’s experience, judgment and performance. Example, using weighted averages to form expected value:

Table 9: Annual maize price variation with weight

Year	Average annual price	Weight price	Result price times weight
4 years ago	2.50	1	2.50
3 years ago	3.05	2	6.10
2 years ago	2.00	3	6.00
Last year	4.50	4	18.00
Total		10	32.60
Weighted average	$32.60/10 = 3.26$		

Most likely method

By this method, an expectation is formed by choosing the value most likely to occur (this is the value that is relatively sure to occur). This procedure requires knowledge of the probability associated with each possible outcome. The outcome with the highest probability would be selected on the likely to occur.

Table 10: Possible maize yield with probability

Year	Possible maize yield (qt/ha) over 4 years	Probability
Year 1	15	0.1
Year 2	18	0.3
Year 3	25	0.4
Year 4	30	0.2
	Total	1.00

Four possible maize yields are shown along with probability of obtaining each yield. Using the most likely method to form an expectation, a yield of 25 quintal per ha will be selected as this yield has the highest probability and is therefore the most likely to occur. However, there is no assurance that this yield will occur in any given year but it will occur 40% of the time over a long period.

Mathematical expectation

When either the true or subjective probability of the expected outcome is available it is possible to calculate the mathematical expectation of yield, price, cost, income or profit. It is given as:

$$E(Y) = \sum(Y_1P_1 + Y_2P_2 + Y_3P_3 + \dots + Y_nP_n)$$

Where E(Y) is the expected yield

Y_1, Y_2, \dots, Y_n are the yield under the various states of nature (wet, dry and normal years)

$P_1, P_2, P_3, \dots, P_n$ are the respective probability of the state of nature.

Example: Let's assume that there are three states of nature based on past experience viz., wet, dry and normal. The probabilities of occurrence of these conditions are 0.2, 0.3 and 0.5, respectively. Consider maize and sorghum yield in the three states of nature as in the following table:

Table 11: Expected maize yield with varying state of nature

Crop	State of Nature			Expected yield
	Wet years	Normal years	Dry years	
Maize	35	25	15	24
Sorghum	15	25	20	22

The expected yield for maize is:

$$E(Y) = (0.2*35) + (0.5*25) + (0.5*15) = 24$$

The expected yield for sorghum is:

$$E(Y) = (0.2*20) + (0.5*30) + (0.3*30) = 22$$

Finally the values 24 and 22 quintals are used for planning purpose.

Decision making under risk

There are several elements or components to any decision involving risk. Here three of them are considered.

There are alternative decisions or strategies available to the decision maker;

There are possible events that can occur, such as variation in weather and variation in price and these factors create the risk because the actual outcome is not known at the time the decision must be made; and

The consequences or result of each strategy (decision) for each possible outcome (event) may be expressed as yield, net returns or some appropriate value.

Example: Consider a fattening program or plan

Assume that a farmer plants alfalfa feed in a given hectare of land in the winter

Oxen are purchased in winter and graze on the alfalfa and sold in the spring

All oxen must be purchased and sold after fattening

Now the farmer's problem is on deciding how many oxen to purchase. That is:

If too few oxen are purchased and the weather is good there will be excess grazing available and opportunity for additional profit is given up.

If too many oxen are purchased and the weather is poor, there will be insufficient forage, so that feed may have to be purchased and profit is reduced or a loss is incurred.

Let's further assume that the farmer has decided on three choices: purchase 30, 40 or 50 oxen. These choices are the decision strategies and the weather can be good, average and poor with probability of 0.2, 0.5 and 0.3, respectively.

The same three weather outcomes are possible for each of the possible strategies. This creates nine potential consequences or results to be considered and it is helpful to organize this information with decision tree or with pay off-matrix.

Decision tree (a diagram that traces out all possible strategies/acts), potential outcome (events and possibility) and their consequences; and is illustrated as follow:

Table 12: Decision strategies with varying state of nature for oxen fattening program

Strategy	Weather outcome	Probability	Net returns	Expected Value
Buy 30	Good	0.2	6000	3800
	Average	0.5	4000	
	Poor	0.3	2000	
Buy 40	Good	0.2	5800	4160
	Average	0.5	5600	
	Poor	0.3	0	
Buy 50	Good	0.2	8000	4000
	Average	0.5	6000	
	Poor	0.3	2000	

The expected values are the summation of the net return weighted by their probability (example, for the buy 30, the expected value is $(0.2*6000) + (0.5*4000) + (0.3*2000) = 3800$ birr).

Pay-off matrix: This contains the same information as the decision tree but is organized in the form of table and is illustrated below.

Table 13: Pay off matrix for oxen fattening program

Weather outcome	Probability	Purchase strategy		
		Buy 30	Buy 40	Buy 50
Good	0.2	6000	6800	800
Average	0.5	4000	5600	6000
Poor	0.3	2000	0	-2000

Minimum Value		2000	0	-2000
Maximum Value		6000	6800	8000
Expected value		3,800	4160	4000
Simple average		4,000	4133	4000

The Decision Rule

The decision rule includes the following: maximin, maximax, maximize expected value and most likely outcome.

Maximin rule: This rule concentrates on the best possible outcome for each strategy. This rule says that nature will always do the worst (pessimistic approach). Therefore, the strategy with the best of the worst possible result is selected, that is, the one with the maximum of the minimum value is selected. From the above table this rule select “buy 30” strategies as its minimum on sequence of birr 2000 is higher than the minimum for the “buy 40 and 50” strategy with the minimum consequence of birr 0 and 2000, respectively.

Maximax rule: This rule is just the opposite of maximum rule. That is, this rule selects the strategy with the highest maximum value or the maximum of the maximum value. This rule says nature will always do its best (optimistic approach). According to this rule “buy 50” strategy will be selected since its maximum value is greater than the maximum value of the other two strategies.

Maximize expected value: In this rule the decision is made by selecting strategy with the highest expected value. Accordingly, this rule selects the “buy 40” strategy since it has the highest expected value.

Most likely outcome rule: By this rule, the outcome that is most likely to occur (one with highest probability) and then the strategy with the highest consequences for that outcome will be chosen. Accordingly, the highest probability (0.5) and the corresponding highest consequence (6000 birr) occur in the “buy 50 strategy”. Therefore, this rule selects “buy 50” strategy.

The use of the different rules depends on the types of the decision maker’s attitude towards risk and the existing financial condition of the business. There are 3 types of persons with regard to their attitude towards risk.

Risk-averse person: Risk avoider person. Usually risk-averse person perform the one that is sure to get with the highest probability even if the result is low. This person usually prefers to use maximin rule for making decision. A person/business with weak financial position mostly prefers to use this rule.

Risk taker (prefer): This is a person who tries to achieve the maximum output under risk condition. This person prefers to use maximax rule for decision making. A person/business with strong financial position mostly prefers to use this rule.

Risk indifferent person: A person who doesn't care whether risk occur or not. This person prefers the last two decision rule to make his/her decision.

Methods of Reducing Risk and Uncertainty

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

Diversification: Production of two or more commodities with negative correlation in their performance parameters may reduce income variability if all prices and yields vary.

Selection of 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.

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 through insurance arrangement.

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.

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.

8. Role of gender in Farm Business and Its Management

Pre-test

- Does every member of your family participate on decisions of resources use?
- How do you rank the decision making power of all household members in your family
- Mention the types of activities normally accomplished by women and those by men
- What is the basis to separate activities done by men and those by women?
- What is gender?

In many societies farm tasks are often gender specific. For example while males plough the land, females may sow, or females may be responsible for water fetching, while males cater for firewood. In farm production the division of labour may be by crop, by field or by task. Within the domestic sphere, women work for the family not only to ensure its reproduction, but also its maintenance and survival. Three major areas where gender role matters in farm business are briefly explained below.

Division of labour in farm production

Tasks in farm production include cultivation, sowing, weeding, fertilizer application, pesticide application, harvesting, processing, storage and marketing. Males and females play their share based on the gender role defined by social system and the requirements of specific tasks such as technical specifications. For instance both may share the tasks on equal basis or each may focus on some activities leaving others to their counterparts (e.g. Men may go fertilization application and women may undertake weeding).

Decision-making on farm production

The production process can be broken into five components: choice of crops (cash or food crop?), time to perform a particular task (e.g. land preparation, sowing or weeding), decision to adopt an innovation and choice of processing and storage method. The decisions on these farm production processes can be made by women, men or both depending on the gender role specified by society which varies from place to place.

Decision making on resource allocation and disposal of produce

Basic farm resources were discussed earlier. A farm family member or groups with final say determines the allocation and use of resources. The outcome of resource allocation and produce disposal decision has a direct implication on which field crop to select; task allocation among household members; decision whether to hire labour; sale of surplus produce; market choice and Livestock purchase.

In summary, gender among other factors, highly influences the performance of farm business. Involvement in the decisions on production, labour division and resources allocation drives the incentive to accomplish farm activities and bear the responsibility for the outcome. Further, considering gender issues will assist to better direct development projects and thus realize project goals as efficiently as possible.

Continuous Assessment

Assignment –students identify specific gender roles in farm business in their locality and discuss in the class

9. Natural Resource and Environmental Economics

Pre-test questions

- Define natural resource economics and environmental economics.
- Mention some services provided by the environment.
- Do you think that property rights have roles in resource use efficiency?

Concepts and Definitions of Natural Resource and Environmental Economics

Natural resource and environmental economics emphasizes the links between the economy and the ecosystem. It adopts a conceptual framework that views the economy as a subsystem of a finite and nonexpanding ecosystem that imposes biophysical limits on economic growth. This framework is consistent with the concept of sustainable development and sustainable resource use. Addressing the interconnections between the economic and ecological spheres requires that natural and environmental resource issues be approached from a multidisciplinary perspective. Natural resource and environmental economics is one of the disciplines in this nexus. Natural resource and environmental economics as a discipline is a relatively recent theme of Economics.

What is Natural Resource Economics? It is the study of how to best govern scarce natural resources, especially, such as air, ground water, marine fishery that are common rather than private properties. The sort of questions and problems to be studied in the area of natural resources economics include production, markets, management, uses, and abuses of natural resources such as fisheries, forests, and non-renewable resources extraction.

What is Environmental Economics? It is the study of the impact of the goods and services produced by economy, particularly market systems of allocation, on environmental quality and ecological integrity. The sorts of questions to be studied under environmental economics include: externality, economics of pollution, targets and instruments for their control, and environmental valuation.

Natural resource and environmental economics, therefore, is the application of the principles of economics to the study of how environmental and natural resources are developed and managed.

Important concepts in Natural Resource and Environmental Economics

Efficiency—is in terms of the missed opportunity. If it is possible to avoid wastage and make some society beneficiary, that resource allocation is said to be inefficient. Example, in the case of energy inefficiency, technical inefficiency, it is possible to avoid through employing different techniques in which resource could be saved without hurting the final output. But economics focus on allocative efficiency. Example it is possible to generate electricity from fossil coal in a technically efficient way, but it produces pollution waste which costs society in terms of health care. If that cost, not paid by the electricity supplier exceed its saving from producing electricity from coal, then it is economically inefficient. This is due to choice in resource allocation; it is possible to produce electricity from less polluting resource. The concern of economics here is to choose the allocation of less polluting resource so that the society as whole will be better off.

Optimality—is related to efficiency but it is distinct from it. To understand this concept has the following in mind:

Some society is there;

Some overall objective that this society has, in terms of which we can measure the extent to which some resource use decision is desirable from that society's point of view.

So, resource use decision is socially optimal if it maximizes that objective given any relevant constraints that may be operating. A resource allocation cannot be optimal except it is efficient. So efficiency is the necessary condition for optimality but not sufficient.

Sustainability—is about taking care of intergenerational equity. Is the optimal allocation of the resource means sustainable? If it is not, the sustainability should be the constraint for optimality.

Economy–Environment Interlinkage

Every economic action can have some effect on the environment, and every environmental change can have an impact in all economic activities. By 'the economy', we refer to the population of economic agents, the institutions they form (which include firms and governments) and the interlinkages between agents and institutions, such as markets. By 'environment', we mean the biosphere, the 'thin skin on the earth's surface on which life exists', the atmosphere, the geosphere (that part of the earth lying below the biosphere) and all flora and fauna. Our definition of the environment, thus, includes life forms, energy and material resources, the high and low atmosphere. These constituent parts of the environment interact with each other. As an example, consider the generation of electricity. In extracting fossil fuels to use as an energy source, we deplete the stock of such fuels in the geosphere. In burning these fuels to release their energy, we also release carbon dioxide (CO₂) and sulphur dioxide (SO₂), both of which may produce undesirable environmental impacts that reduce human (and, therefore, economic) well-being.

The interlinkages between the economy and the environment are summarized in Figure 4. Here we simplify the economy into two sectors: production and consumption. Exchange of goods, services and factors of production takes place between these two sectors. The environment is shown here in two ways: as the three interlinked circles E₁, E₂ and E₃, and the all-encompassing boundary labeled, E₄. The production sector extracts energy resources (such as oil) and material resources (such as iron ore) from the environment. These are transformed into outputs; some useful (good and services supplied to consumers) products and some waste products, such as SO₂. There is some recycling of resources within the production sector, shown by the loop R₁, and within the consumption sector, as shown by the loop R₂.

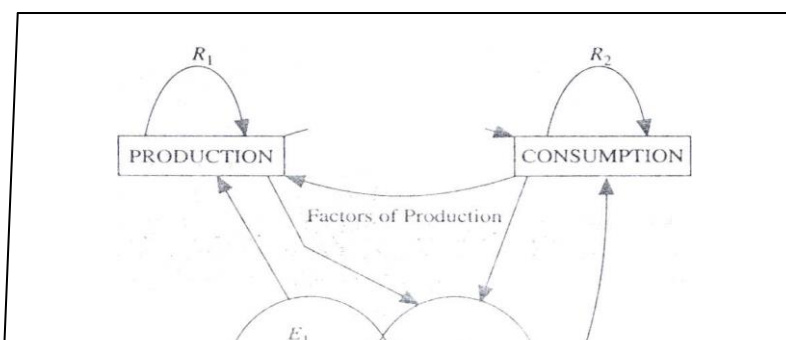


Figure 3: The economy-environment interlinkage

The environment's first role, then, is it serves as a supplier of resources. Its second role is as a sink, or receptor, for waste products. These wastes may result directly from production, as already mentioned, or from consumption: when an individual puts out garbage, or when they drive to work, they are contributing to this form of waste. In some cases, wastes are biologically and/or chemically processed by the environment. For example, organic emissions to an estuary from a distillery are broken down by natural processes—the action of micro-organisms into their chemical component parts. Whether this results in a harmful effect on the estuary depends on a number of factors, including the volume of waste relative to the volume of receiving water, the temperature of the water and its rate of replacement.

For some inputs to the environment, there are no natural processes to transform them into harmless, or less harmful, substances. Such inputs, which are variously termed 'cumulative' and 'conservative' pollutants, include metals such as lead and cadmium, and man-made substances such as PCBs (polychlorinated biphenyls) and DDT (dichloro-diphenyl-trichloro-ethane). If, in our estuary example, PCBs are discharged into the water, then they will not be broken down by either chemical processes' (oxidation) or through biological processes by micro-organisms.

So far we have seen that the environment acts as a waste sink, as a partial recycling factory for human wastes from production or consumption and as a source of energy and material resources. The next role to be considered is that marked E_3 in Figure 4. The environment acts as a supplier of amenity, educational and spiritual values to society. For example, people in Europe may derive pleasure from the existence of wild life in tropical moist forests ('rainforests'), while native peoples living in these areas attach spiritual and cultural values to them, and the flora and fauna therein. We need to make precise the sense in which such values 'count' for economists.

What this simple example shows is that using the environment for one purpose (as a supplier of material resources) can reduce its ability to supply us with other services, such as the ability to breath clean air. This is why in Figure 4 the three circles E_1 , E_2 and E_3 are shown as overlapping: there are conflicts in resource use. These conflicts would include the following:

- using a mountain region as a source of minerals means its amenity value is reduced;

- using a river as a waste-disposal unit means its amenity value is reduced and that we can no longer extract so many material resources (fish to eat) from it;
- felling a forest for its timber reduces the electricity-generating capacity of a dam, owing to soil erosion, and reduces amenity values since the forest's inhabitants (animal and human) are displaced or destroyed;
- preserving a wetland for its aesthetic qualities forgoes use of the drained land for agriculture.

The environment is, thus, a scarce resource, with many conflicting demands placed on it. Returning to Figure 4, the boundary marked E₄ represents the global life-support services provided by the environment. These include:

- Maintenance of an atmospheric composition suitable for life.
- Maintenance of temperature and climate.
- Recycling of water and nutrients.

Property Rights and Externalities

Markets and efficient property rights markets

While it is possible to achieve efficient resource use without reliance on markets, the informational and computational requirements are very high. An alternative to a market economy is a centrally planned economy. A *centrally planned economy* is a form of economic organization in which decisions regarding what to produce, how much to produce, where to produce, how to distribute production, and the level of resource and commodity prices are determined by government units. Efficient use of resources in a centrally planned economy requires information on input requirements and output possibilities of alternative production technologies for all locations and points in time; consumers' willingness to pay for all commodities over time and space; and transportation, marketing and distribution requirements and costs. Based on this information, the government units have to determine the production, consumption and prices for all resources and commodities for all regions and time periods. Therefore, a centrally planned economy requires the orchestration of, literally, thousands of economic decisions.

Purely competitive markets automatically achieve efficient resource use through the independent profit-maximizing behavior of firms and the independent utility-maximizing behavior of households, provided there exists an efficient set of property rights. *Property rights* are institutional rules that govern and facilitate the use and exchange of resources and commodities. Efficient property rights are a prerequisite for market transactions.

Market equilibrium price and quantities are influenced by the specification of property rights. This is illustrated in Figure 4, which shows the market demand and supply curves for an agricultural crop under pure competition. Under pure competition a) there is a large number of producers and consumers; b) no single producer or consumer can influence the price received or paid for the product; and c) there is no uncertainty regarding production technologies, consumer preferences and prices. In Figure 4, D is the market demand curve. It has a negative slope because buyers are willing to purchase additional units of the crop as the price of the crop decreases, other things equal. Marginal cost (MC) is the market supply

curve that is the sum of the marginal cost curves above average variable costs for all firms producing the crop. It is positively sloped because sellers are willing to sell more of the crop as the price increases. The profit maximizing level of crop production is where $P_r = MC$ or is also known as the privately efficient level of production.

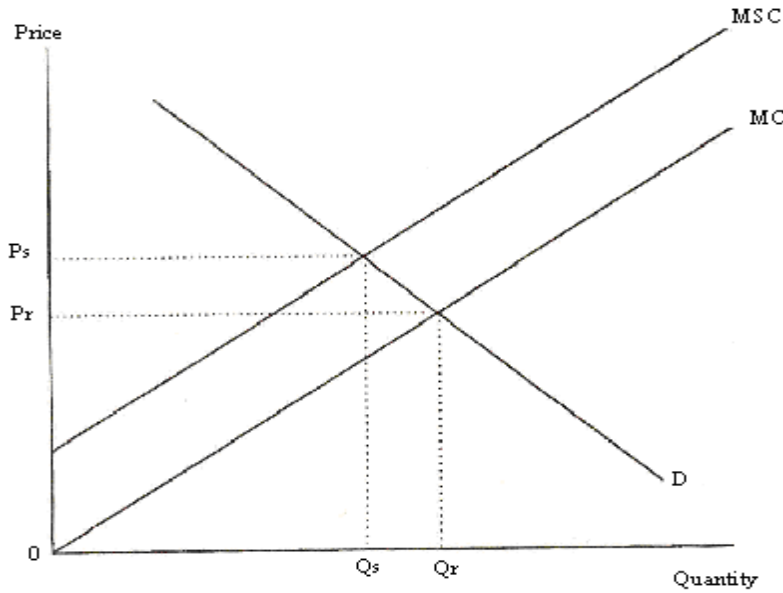


Figure 4: Market Equilibrium

Privately efficient crop production (Q_r) and price (P_r), and socially efficient crop production (Q_s) and price (P_s), in a purely competitive market, $D =$ demand; $MC =$ marginal cost; and $MSC =$ marginal social.

In selecting the profit maximizing output, firms typically do not consider environmental damages caused by production. For example, runoff from agricultural fields carries sediment, fertilizers and pesticides to nearby streams and lakes, which can result in water pollution. Marginal cost excludes damages caused by water pollution. Adding the marginal environmental damages from crop production to MC gives the marginal social cost (MSC) of crop production. The socially efficient level of crop production is Q_s where $P_s = MSC$.

When farmers have a right to pollute water, they ignore the environmental damages from crop production and select the privately efficient level of crop production, which is Q_r . Because $MSC > MC$, $Q_s < Q_r$ and $P_s > P_r$, production and pollution are higher and prices are lower when producers have the right to pollute water. When producers do not have the right to pollute water, society has the right to take action to reduce pollution damages. Suppose this action is in the form of a tax on production. Imposition of the tax causes the MC curve to shift upward by the amount of the tax. An increase in MC causes the profit maximizing production level to decrease. If the tax equals the difference between MSC and MC , then the market achieves equilibrium where $P = MSC$ and the privately efficient level of production equals the socially efficient level of production.

Efficient Property Rights

Property rights are efficient if they satisfy four basic properties: *ownership, specificity, transferability and enforceability*. Ownership is the legal mechanism for conveying property rights to a resource. It determines who has the legal right to use a resource. In cases where resources are privately owned, ownership is secured by payment in an amount that is mutually agreeable to buyer and seller. Several types of ownership are possible. At one extreme is exclusive ownership, which is the most restrictive form of ownership. *Exclusive ownership* of a resource requires that all benefits and costs associated with the ownership and use of the resource be borne by the owner. Suppose odor from a paper mill pollutes the air in a nearby community. If the cost of air pollution is not considered by the paper mill, then, owner exclusivity is violated. *Exclusive ownership* allows the resource owner to let another party use the resource through different mechanisms like leasing. At the other extreme of the ownership spectrum is *res nullius* which means that the property belongs to no one. While exclusive ownership allows the resource to be bought and sold, *res nullius* prevents it. Another form of ownership is *res communis*, which refers to common or communal property that is owned and/or managed by a group of kindred individuals, such as a tribe or clan.

Specificity of property rights refers to the bundle of rights that apply to a particular property. It determines what can and cannot be done with the resource. Consider what happens when the cattle owned by a rancher graze on a neighbor's land, causing damages to the land. The neighbor's property rights are being violated if the rancher does not have permission to graze cattle on the neighbor's land. Under this specification of property rights (lack of permission to graze), the rancher is legally required to keep the cattle off the neighbor's land. If the neighbor's land is designated as open range, however, then the rancher has a right to graze cattle on the neighbor's land. Under this specification of property rights, the only feasible way to keep the cattle off the neighbor's land is for the neighbor to install fencing, which is costly. If cattle grazing are not covered by a property right, then a conflict is likely to arise between the rancher and the neighbor. Resource conflicts can be resolved when the rights of the rancher and the neighbor are completely specified.

An efficient property right is *transferable*, which allows resources to be allocated to their highest valued use. Transferability of one or more elements in a bundle of property rights makes possible the leasing of private land, creation of utility easements and the existence of restrictive covenants.

Ownership, specificity and transferability of property rights are of limited value in achieving efficient resource use without enforceability. *Enforceability* requires that the property right be enforceable and enforced when there is a violation. A right that is not enforceable is of little value.

Even when enforceability is feasible, violations can occur. Two types of violations are possible: unintentional and intentional. An unintentional violation is one that occurs even though best management practices are being followed. Phosphorus pollution of the lake by nearby farms is likely to occur when there is a heavy rain on the day following application of manure. This type of pollution is unintentional. Pollution of the lake by industrial sources would be intentional when the industry knowingly releases an amount of phosphorus to the lake that exceeds the standard. Industrial sources might risk paying the fine when the

expected penalty (probability of a being caught times the amount of the fine) is less than the expected benefit of exceeding the standard (reduction in phosphorus disposal costs).

Transaction Costs

While establishment of efficient property rights is a necessary condition for efficient resource use under pure competition, it is not costless. The costs of achieving efficient property rights are called *transaction costs*. Transaction costs are usually small when only a few individuals are involved and the conflict is minor. However, transaction costs can be high when many parties are involved.

Resolving resource conflicts constitutes a major perennial transaction cost. Examples of resource conflicts in the Ethiopia include competition between agricultural, access to and/or use of public lands for grazing, timber harvesting, water supplies, recreation and endangered species; encroachment of prime agricultural areas by urban development and others. On a global scale, resource conflicts are caused by global warming, deforestation, ozone depletion and loss of biological diversity. Finally, enforcement of property rights entails major costs.

Market Failure

There are three conditions under which operation of markets fails to achieve efficient resource use:

- The market is not purely competitive.
- The resource is a common property or open access resource.
- There are externalities.

Each of these conditions constitutes a *market failure*. The failure does not mean there is something morally or ethically wrong with the market. Rather, it implies that the prices generated in the market do not provide firms and households with the incentives needed to achieve socially efficient resource use.

Common Property and Open Access Resources

Natural resources can be managed as common property or open access resources. Common property resources are resources that are owned in common and managed for a common purpose. Owners have exclusive rights to the property but cannot exclude one another from using it. There may or may not be restrictions on how frequently owners may use the resource. If frequency of use is not restricted, as in a city park, then the resource tends to be overexploited, which results in Garrett Hardin's tragedy of the common. If frequency of use by owners is restricted like the tribal grazing lands in African countries, overexploitation can be avoided. *Open access resources* are not owned by anyone (*res nullius*). Thus, it is not practical to exclude others from using them, and there is generally no incentive for an individual to limit his or her use of the resource. An example of an open access resource is the ocean fisheries.

Externalities

Of the three sources of market failure just described, externalities have received the most attention in natural resource and environmental economics. An externality exists when the activities of an acting party influence the welfare of an affected party and the acting party does not consider how its activities affect the welfare of the affected party. The acting party is

the party engaged in the activity responsible for the externality, and the affected party is the party whose welfare is influenced by the externality. The acting and affected party can be a household or a firm. Hence, externalities can take place between firms, between households, and between households and firms. If the acting party engages in an activity for the sole purpose of harming or benefiting the affected party, then the activity does not constitute a true externality.