2

Principles of Production Economics and Cost Concepts

OBJECTIVES

- **To explain the production function, the law of diminishing returns and marginalism in simple language.**
- **To indicate how the most profitable production level (optimum production) can be achieved.**
- **To explain the optimum combination of inputs.**
- **To compare various product relationships (complementary, competitive, etc.).**
- **To describe and explain some cost concepts in agricultural production.**

Agricultural production involves the combination and conversion of four production factors, namely land, capital, labour and entrepreneurship into useful products such as food, fibre, timber, liquor and tobacco. An example of this is the combination of seed, fertiliser, diesel, water, chemicals, labour and equipment to produce wheat, oats or maize. In this production process the farmer has to make decisions on the following:

- What to produce;
- How to produce; and
- How much to produce.

At first glance it would seem as if the answer to — particularly the last question — is fairly simple, namely to produce as much as possible. This answer is, however, very wide of the mark and not so simple. The same applies to the other two questions concerning *what* and *how* to produce. To find rational answers to these questions, the farmer must be guided by certain economic principles and certain cost relations. This field of knowledge is known as production economics and cost principles, and includes aspects such as the production function, the law of diminishing returns, marginalism and cost concepts and relations.

Knowledge of and insight into these economic principles are important since relationships between them largely determine the profitability of production. These principles will, however, be better understood if they are studied according to certain premises. These premises include that the individual farm functions independently of other similar production units, that products produced by the farm are homogeneous in respect of quality, that production supplies are freely interchangeable between different uses, and that there is certainty about costs and prices.

Because of these theoretical premises, the discussion of the economic principles in this chapter is basic, brief and to the point.

THE PRODUCTION FUNCTION

Put simply, a production function indicates the relationship between an output (grain) and an input (fertiliser). Put differently:

> *A production function* indicates the relationship between different quantities of a specific output and the inputs responsible for this.

The production function can basically be represented in three different ways. Firstly as an *equation* such as the following:

$y = f(x_1/x_2........x_n)$

where y is the output (grain), x_1 is the variable input (seed) and $x_2....x_n$ the inputs that are kept constant such as fertiliser, water, etc.

A second method of representing a production function is by means of a *table* such as the following:

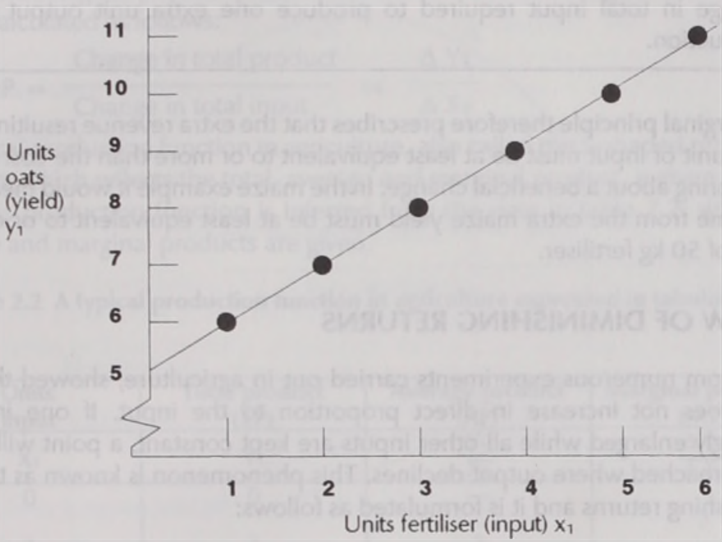
The third and most common way to depict production functions, is by means of

Table 2.1 A production function of fertiliser input to oats yield

Inputs of fertiliser (x_1)	Units of oats yielded (y_1)
0	5
1	6
2	7
3	8
4	9
5	10
6	11

a *graph* such as presented in figure 2.1. Here the data in table 2.1 are presented graphically:

Figure 2.1 A linear production function with fertiliser as input and oats as yield



It is clear from the above that a production function can be presented as an equation, a table or a graph. In a later section more will be said about the typical production function in agriculture.

MARGINALISM (THE MARGINAL PRINCIPLE)

Marginalism is the concept used to explain the influence of a change. It is especially used by economists because they are very interested in the influence of any change. Marginalism is, however, also important for farmers when they have to decide what, how and how much they should produce.

Marginalism basically means the influence or effect that a change in the input will have on the output. That is, what "extra" or "additional" yield or loss will result from a change in the input. A practical example of marginalism is what difference there is in maize yields if 150 or 200 kg fertiliser is applied while all other inputs are kept constant. It therefore concerns the additional maize crop that is harvested with the extra 50 kg fertiliser; this is briefly called the marginal maize yield.

This change in output or input is denoted by the Greek letter delta (Δ). The marginal or extra maize yield will then be written as the Δ *maize yield* and the change in fertiliser application as the Δ *fertiliser input*.

– The *marginal yield* is therefore the change in the total yield or production brought about by one extra input. Correspondingly, *marginal input* is the change in total input required to produce one extra unit output or production.

The marginal principle therefore prescribes that the extra revenue resulting from an extra unit of input must be at least equivalent to or more than the cost of that input to bring about a beneficial change. In the maize example it would mean that the income from the extra maize yield must be at least equivalent to or exceed the cost of 50 kg fertiliser.

THE LAW OF DIMINISHING RETURNS

Results from numerous experiments carried out in agriculture, showed that the output does not increase in direct proportion to the input. If one input is increasingly enlarged while all other inputs are kept constant, a point will eventually be reached where output declines. This phenomenon is known as the law of diminishing returns and it is formulated as follows:

Diminishing returns, also known as declining productivity, occurs where every additional input leads to a smaller increase in output than was obtained with the previous input.

This phenomenon or law is largely responsible for the typical production function that occurs in agriculture.

THE TYPICAL PRODUCTION FUNCTION IN AGRICULTURE

To gain a better understanding of the typical production function in agriculture, it is necessary to consider the *total, average* and *marginal physical product*.

The *total physical product* is the same as the total yield or total output, and indicates the quantity of output/yield that can be obtained with a certain quantity of inputs. This is known as the total product (TP) and is indicated by the symbol Y_1.

The *average physical product* is the quantity output per unit input. This is known as average product (AP) and is calculated as follows:

$$AP = \frac{\text{Total product}}{\text{Total input}} \quad \text{or} \quad \frac{Y_1}{X_1}$$

The *marginal physical product* is the extra output for one unit increase in input, that is the addition to the total product as a result of the addition of an extra unit input. The marginal physical product is also known as the marginal product (MP) and is calculated as follows:

$$MP = \frac{\text{Change in total product}}{\text{Change in total input}} \quad \text{or} \quad \frac{\Delta Y_1}{\Delta X_1}$$

A typical production function in agriculture, also called the S-shaped production function, which reflects the total, average and marginal product, is given in figure 2.2. This production function is inferred from the data in table 2.2, where the average and marginal products are given.

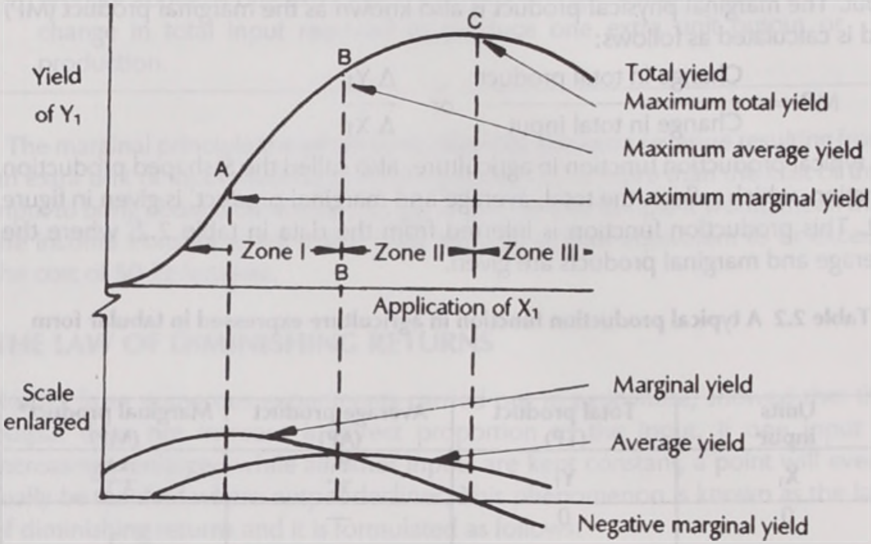
Table 2.2 A typical production function in agriculture expressed in tabular form

Units input	Total product (TP)	Average product (AP)	Marginal product* (MP)
X_1	Y_1	$\frac{Y_1}{X_1}$	$\frac{\Delta Y_1}{\Delta X_1}$
0	0	—	
			3
1	3	3	
			9
2	12	6	
			12
3	24	8	
			14
4	38	9,5	
			15
5	53	10,6	
			14
6	67	11,2	
			11
7	78	11,1	
			8
8	86	10,8	
			6
9	92	10,2	
			4
10	96	9,6	
			2
11	98	8,9	
			- 4
12	94	7,8	

* Note that the marginal product is written between the lines.

As already mentioned, a production function can also be expressed in the form of a graph. Figure 2.2 shows a typical production function that displays the same basic characteristics as the figures in table 2.2.

Figure 2.2 The typical production function with one variable input



It is clear from figure 2.2 that the typical production function in agriculture can be divided into three zones, namely I,II and III. These zones are sometimes also called production stages and represent the three different relations between a single input and a single output.

Zone I: In the first zone the yield increases at a rising rate up to point A, known as the inflection point. The average yield per unit, however, continues to increase after point A has been reached up to point B, where the highest average product is achieved. Up to point B the marginal product is higher than the average product and the two intersect at point B. This stage represents an irrational production area since the average product continues to increase, that is, each additional unit input leads to a bigger increase in output than that caused by a previous unit input.

Zone II: In this zone the output/yield/total product continues to increase but at a declining rate. Zone II therefore lies in the area between the maximum average product and the maximum total product. This is known as *the rational production zone* because the most profitable production level occurs in this zone.

Zone III: This zone extends from the maximum total product and is, like Zone I, also an irrational production zone. This is due to the fact that the marginal product becomes negative as a result of a drop in the total product. Even if it had been possible to add inputs free of charge, it would be senseless because each additional unit input results in an absolute drop in yield. A practical example of this is the addition of more and more water until the soil is in a water-logged condition.

As already mentioned, the most profitable level of production is found in Zone II. The question is, however, where in Zone II? To answer this question, the price of the product and the cost of the input must be known. Thus far, only *physical* quantities and *physical* relationships have been relevant, and although it is important to take note of these, it is necessary to know the value of outputs and inputs to make economic decisions. The first problem that demands further attention is *how much* must be produced in economic terms, while the other two questions, namely *how* and *what* to produce, will then be discussed.

HOW MUCH TO PRODUCE

From what has been said so far, it is clear that production will not be attempted in Zone I or Zone III. In Zone I the average product for each unit of input continues to rise, while in Zone III the total product declines for each extra unit input. The optimum point or most profitable level should therefore lie in Zone II.

Put simply, the optimum point occurs where the additional income from an extra unit output is at least equal to,or greater than,the cost to produce it. The farmer will, for example, increase his fertiliser application to the level where the extra revenue from the increased maize yield at least equals the cost of the last bag or unit of fertiliser.

To illustrate the above more clearly, the information in table 2.2 is used and two new concepts (and columns) are added, namely the *value* of the *marginal* product (VMP) and the *input price* (PX). The *value* of the marginal product (VMP) is the marginal product (MP) multiplied by the price of the product (PY_1), that is:

$$VMP = MP \cdot PY \text{ or } \frac{\Delta Y_1}{\Delta X_1} \cdot PY$$

The input price is the price per unit input and is given as PX.

The most profitable level of production is where VMP = PX, and according to table 2.3 this is between 8 and 9 units input because the VMP of R12 then equals the PX of R12. [Argued differently, the most profitable level is found where marginal *income* equals *marginal cost*, or $PY(\Delta Y) = PX(\Delta X)$.]

It is also apparent from table 2.3 that the highest profit is made at the optimum level of production, namely a profit of R76 that is realised at an input of 8 or 9 units. In this instance 8 units will be preferred, but in reality the highest profit is between 8 and 9 units, which will then be slightly more than R76.

Table 2.3 Calculation of the optimum production level at an input price of R12 per unit and an output price of R2 per unit

Units input	Total product	Marginal product	Total product value	Value of marginal product	Total input costs	Input price	Total profit
X_1	Y_1	$\frac{\Delta Y_1}{\Delta X_1}$	(Y_1 xR2)	VMP (MP · PY)	(Input x R12)	PX	TP value less total input costs
0	0		0		0		
		3		6		12	
1	3		6		12		- 6
		9		18		12	
2	12		24		24		0
		12		24		12	
3	24		48		36		12
		14		28		12	
4	38		76		48		28
		15		30		12	
5	53		106		60		46
		14		28		12	
6	67		134		72		62
		11		22		12	
7	78		156		84		72
		8		16		12	
8	86		172		96		76
		6		12		12	
9	92		184		108		76
		4		8		12	
10	96		192		120		72
		2		4		12	
11	98		196		132		64
		- 4		-8		12	
12	94		188		144		44

HOW TO PRODUCE

Thus far a single variable input has been used in discussing production decisions. In the practical situation on the farmer's farm, however, more than one input is used to produce a specific product. Moreover, the farmer usually has to make a choice between different types and different quantities of inputs. He is therefore faced with the choice of substitution, which means that one type or quantity of a specific input can be replaced by a different type or quantity.

Substitution of inputs is common in agriculture and they vary not only on the same farm, but also from one farm to the next and from season to season. If, for example, maize as a ration is scarce or too expensive in a specific year, it can be replaced by grain sorghum or wheat. Organic instead of inorganic fertiliser can be used, and manual labour can be replaced by a tractor. The farmer therefore has to make a choice between the different options and pursue that combination of inputs that will have the lowest production cost per unit output. The problem is naturally to find this specific combination where the lowest cost combination is achieved without sacrificing quality or quantity. This is an aspect to which farmers must pay constant attention.

The first step in choosing between inputs is to know the substitution ratios that may occur between inputs. In the equation

$Y_1 = f(X_1, X_2/X_3.....X_n)$

X_1 and X_2 represent the two variable inputs, while $X_3.....X_n$ represent the fixed inputs. The two inputs X_1 and X_2 can substitute one another in different ratios without influencing the yield Y_1 or the fixed inputs. This ratio of substitution or substitution rate of inputs is calculated as follows:

$$\text{Physical substitution ratio} = \frac{\text{Quantity of replaced input } (\Delta X_2)}{\text{Quantity of the added input } (\Delta X_1)}$$

The ratio in which the inputs replace one another is naturally not directly proportionate - it will differ from situation to situation. Basically, a distinction is made between three types of physical substitution ratios, namely a *fixed ratio* (fig.2.3), a *constant ratio* (fig.2.4) and a *decreasing ratio* (fig.2.5).

Figure 2.3 A fixed substitution ratio

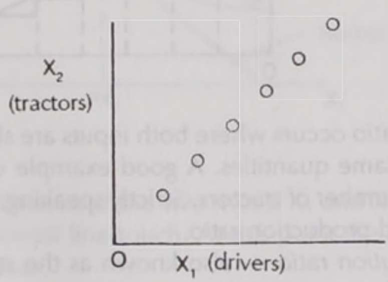


Figure 2.4 A constant substitution ratio

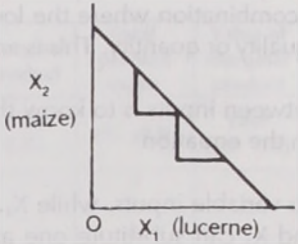
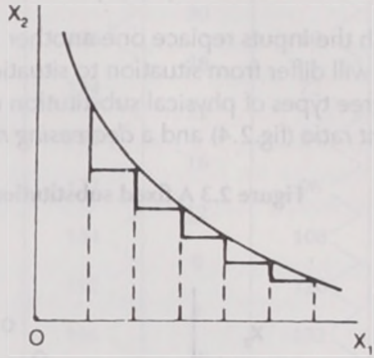


Figure 2.5 A decreasing substitution ratio



A *fixed substitution ratio* occurs where both inputs are simultaneously increased or decreased by the same quantities. A good example of this is the number of tractor drivers to the number of tractors. Strictly speaking, this is not a substitution ratio, but rather a fixed production ratio.

The *constant substitution ratio* — also known as the straight-line ratio, occurs where one input X_1 always replaces an equal quantity of another input /X_2. An example of this is two bales of lucerne hay for each unit of maize in a specific feed ration.

A decreasing substitution ratio refers to the situation where more and more units of X_1 have to be used to replace one unit of X_2 as the quantity of X_1 increases. Many substitution ratios in agriculture are examples of the decreasing substitution ratio and make substitution more difficult because relatively more of the added input must be used to maintain the yield level.

To determine the lowest cost combination of inputs, the physical substitution ratio or the substitution rate must be known. But this is not all. The prices of inputs must also be known so that the price ratio between inputs can be calculated. This is done as follows:

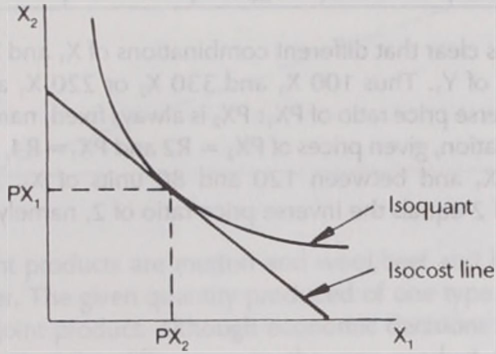
$$\text{Price ratio of inputs} = \frac{\text{Price of replaced input } (PX_2)}{\text{Price of the added input } (PX_1)}$$

The lowest cost combination then occurs where the physical substitution rate equals the inverse price ratio. In the form of an equation it can be written as follows:

$$\text{Lowest cost combination of inputs:} \quad \frac{\Delta X_2}{\Delta X_1} = \frac{PX_1}{PX_2}$$

The application and further explanation of this principle emerge from figure 2.6 and table 2.4

Figure 2.6 Lowest cost combination of two inputs



The lowest cost combination of the two inputs X_1 and X_2 in figure 2.6 is where the isoquant and the isocost line touch. At this point the slope of the curve and the line equal one another.

An *isoquant* reflects the physical substitution ratio between X_1 and X_2 and, as can be seen in figure 2.6, X_2 increases as X_1 decreases. The product Y_1 which is represented by the isoquant, does not change however. The *isocost curve* reflects the price ratio between X_2 and X_1, for example PX_2= R4 and PX_1= R3. The isoquant represents a physical/biological ratio and is usually fixed, while the isocost curve's slant changes if the price ratio between the two inputs changes.

The preceding explanation can also be elucidated by means of a table (see table 2.4).

Table 2.4 Lowest cost combination of two inputs to produce 100 units Y_1 (Price X_1 = R4 and PX_2 = R2)

Combinations of X_1 and X_2 for 100 Y_1	Units X_1	ΔX_1	Units X_2	ΔX_2	Substitution ratio $\frac{\Delta X_2}{\Delta X_1}$	Inverse price $\frac{PX_1}{PX_2}$
A	100		330			
		20		90	4,5	2
B	120		240			
		20		70	3,5	2
C	140		170			
		20		50	2,5	2
D	160		120			
		20		40	2,0	2
E	180		80			
		20		30	1,5	2
F	200		50			
		20		20	1,0	2
G	220		30			

From the table it is clear that different combinations of X_1 and X_2 can be used to produce 100 units of Y_1. Thus 100 X_1 and 330 X_2 or 220 X_1 and 30 X_2 can be combined. The inverse price ratio of PX_1: PX_2 is always fixed, namely 4/2 = 2. The lowest cost combination, given prices of PX_2 = R2 and PX_1= R4, lies between 160 and 180 units of X_1 and between 120 and 80 units of X_2. At this point the substitution ratio of 2 equals the inverse price ratio of 2, namely:

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

$$\frac{40}{20} = \frac{4}{2}$$

or $2 = 2$.

If the data in table 2.4 should be represented graphically, it would be the same as in figure 2.6, namely that the isoquant and the isocost line touch, and that the slope of the curve (isoquant) at this point is equal to the slope of the isocost line.

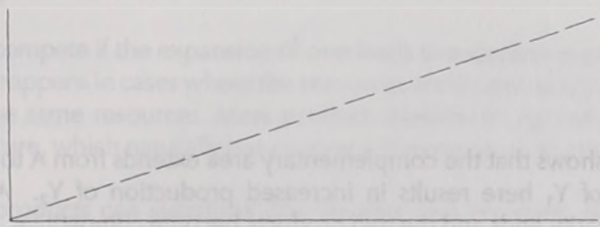
WHAT TO PRODUCE

The final question that remains to be answered, is what to produce. Put differently: the best combination of production branches must be found so as to maximise profits. On some farms this choice is a relatively simple one, since physical resources can only be applied to a single type of crop or a single livestock branch. On other farms the choice is made more difficult because of the wide range of potential uses, for example, sheep, cattle or goats, or for maize, grain sorghum or sunflower. The problem is further complicated by the fact that the different branches — in most cases — compete for the same resources. An expansion of one branch is therefore at the expense of another, and such branches are known as competing products or branches.

As was the case in the problem of how to produce, it is necessary to first consider the different types of physical relationships that can exist between products. Four such product relationships are of importance, namely joint products (fig.2.7), complementary products (fig.2.8), supplementary products (fig.2.9) and competitive products (fig.2.10).

Joint products

Figure 2.7 Joint product relationship



Examples of joint products are mutton and wool,beef and hides, maize kernels and maize stover. The given quantity produced of one type also determines the quantity of the joint product. Although economic decisions are relatively simple in these instances, price differences in the one product may well affect the production of the other. For example, should the wool price increase sharply, this could result in a shift to woolled breeds which would in turn bring about a drop in the production of mutton.

Complementary products

Two products are complementary when an increase in the production of one leads to an increase in the production of the other. This situation is illustrated in figure 2.8. The difference between joint and complementary products lies in the fact that the relationship between the two in the latter instance is not fixed. This means that if the production of A is increased, it will not, in the case of joint products, always lead to an increase in the production of B. An increase in mutton production in a specific flock will not necessarily result in higher wool production.

Figure 2.8 Production potential curve for two complementary products

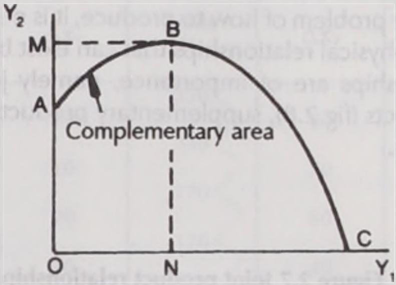
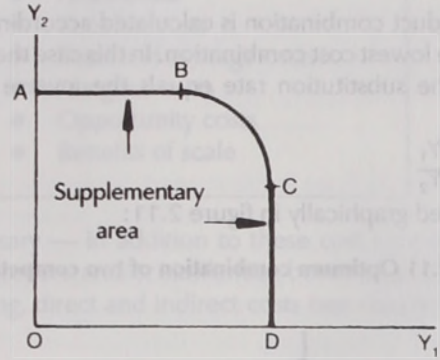


Figure 2.8 shows that the complementary area extends from A to B because the production of Y_1 here results in increased production of Y_2. After this point complementarity ends and the two products become competitive. An example of this is the inclusion of legumes in a rotational system which makes nitrogen available for future crops.

Supplementary products

Two products are supplementary if production of one can be increased without affecting production of the other. This is illustrated in figure 2.9.
Figure 2.9 shows that the two products are supplementary between A and B and between C and D. In the area AB the production of Y_1 can be expanded without affecting Y_2. The opposite is true for the area CD where Y_2 can be expanded without a positive or negative effect on Y_1. In the area BC the products are, however, competitive. An example of this is where cattle graze on young wheat lands; if the grazing period is not too long, it does not affect the wheat yield. The same applies in cases where labourers are used for other purposes on the farm during the so-called slack times. Any supplementary relationship must be exploited on the farm by expanding production of both products at least to the point where they become competitive.

Figure 2.9 Production potential curve for two supplementary products

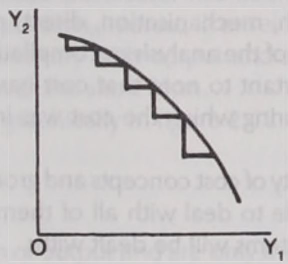


Competitive products

Two products compete if the expansion of one leads to a decline in production of the other. This happens in cases where the resources are limited and both products compete for the same resources. Most product relations in agriculture are of a competitive nature, which naturally has a strong influence on production decisions on a farm.

Competitive products can substitute one another at a constant, decreasing or increasing rate. The latter two possibilities arise as a result of changes in physical relationships, for example if maize is grown as a succeeding crop on potato lands. In the first year after potatoes were grown, the production potential of maize is higher, because of higher nutrient reserves in the soil, than in later years. Since rational production presupposes diminishing returns, the relationship between competing products will in most cases display an increasing substitution rate. This is illustrated in figure 2.10.

Figure 2.10 Production potential curve for two competitive products with an increasing substitution rate



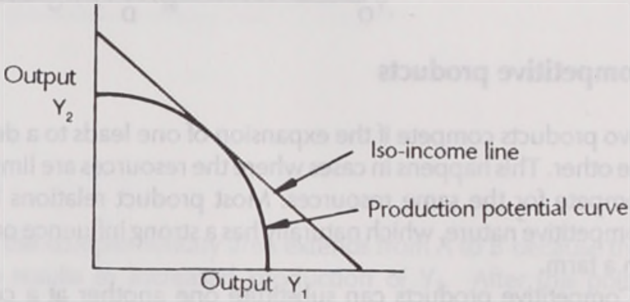
Determining the optimum product combination

The optimum product combination is calculated according to the same principle and method as the lowest cost combination. In this case the optimum combination is found where the substitution rate equals the inverse price ratio of the two products, that is

$$\frac{\Delta Y_2}{\Delta Y_1} = \frac{PY_1}{PY_2}$$

This is represented graphically in figure 2.11:

Figure 2.11 Optimum combination of two competitive products



COST CONCEPTS

In addition to the preceding principles of production economics, a knowledge of certain cost concepts is also necessary for making rational production decisions. It is, unfortunately, true that *cost* sometimes leads to much confusion. This confusion usually arises from the wide variety of cost items that occur in agricultural production, and the different ways in which cost items can be grouped together. This confusion is, however, unnecessary once it is realised that the same cost item can be included in different cost groups, depending on the purpose for which and the period in which the cost was incurred. A cost item such as diesel can, for example, form part of cash, mechanisation, direct, production or variable costs, depending on the purpose of the analysis or compilation of the specific cost group. Concerning this it is important to note that cost has a time dimension. Without reference to the period during which the cost was incurred, a cost figure has no meaning.

Because of the wide variety of cost concepts and groupings that occur in a farming enterprise, it is not possible to deal with all of them in a single section. For this reason only the following items will be dealt with:

- Fixed costs
- Variable costs
- Total and average costs
- Marginal costs
- Opportunity costs
- Benefits of scale

It is, however, necessary — in addition to these cost concepts — also to take cognisance of the differences and/or similarities between production, marketing, administrative, financing, direct and indirect costs (see chapters 6 and 7).

Fixed costs

Fixed costs constitute that portion of the total cost that remains unchanged for a specific production plan regardless of whether more or less is produced. Fixed costs are therefore non-variable in the short term. They may, however, vary over the long term as a result of a change in the production plan.

> If a farmer has erected a milking shed for 50 cows, that is his production plan. The *fixed costs* of the shed, such as interest on the capital and depreciation of equipment, will therefore remain fixed regardless of whether the farmer uses it for 10 or for 50 cows. However, should the farmer change his production plan and extend the shed to accommodate 80 cows, the fixed costs will also change because the production plan has changed.

Examples of *fixed costs* are *depreciation, interest, insurance premiums, rental* and *permanent labour*.

Costs are only fixed once they have been incurred. Before a tractor is bought, all tractor costs are variable. Once the tractor has been purchased, the fixed costs pertaining to it, such as depreciation, interest, licenses and insurance are, however, fixed. These cost items do not vary with output and are therefore not influenced by changes in production over the short term.

Fixed costs are presented graphically in figure 2.12.

Variable costs

Variable costs are a function of output and are only incurred if there is production.

There is therefore a relationship between the volume of production and costs.

> If a farmer milks only ten cows, his *variable costs* such as milkers' wages, concentrates, silage and transport costs of milk are less than would have been the case if he milked 50 cows.

Examples of variable costs are *fertiliser, seed, herbicides, contract work, livestock remedies, licks, concentrates, fuel, seasonal labour, packaging material* and *marketing costs*.

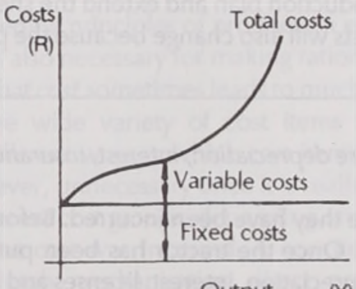
If production decisions have to be made on the quantities of variable inputs that must be used to maximise profit over the short term, only variable costs are relevant since fixed costs remain constant.

Variable costs depend on the production function concerned and, in the case of constant, decreasing or increasing productivity, could be illustrated by a figure similar to the S-shaped production function. The cost function, however, would represent a mirror image of the specific production function (see fig.2.2).

Total costs

Total costs are the sum of the total fixed and total variable costs and will, in the case of decreasing productivity, be as depicted in figure 2.12.

Figure 2.12 The total cost function with decreasing productivity



Average costs

Average or unit costs are the costs per unit such as cost per ton, per hectare, per tree or per litre. Average fixed, average variable and average total costs can, depending on the circumstances, be calculated by dividing the specific cost amount by the corresponding units.

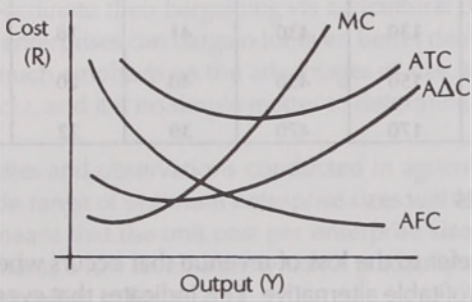
Marginal costs (MC)

Marginal costs are the extra or additional costs attached to the last unit of output. Marginal costs are calculated by dividing the change in costs (Δ costs) by the change in output (ΔY_1), that is:

$$\frac{\Delta \text{ Costs}}{\Delta Y_1}$$

Marginal costs are only determined by an increase in variable costs. As long as marginal income is bigger than marginal costs, the profit will be increased. A graphic illustration of average total costs (ATC), average variable costs (AΔC), average fixed costs (AFC) and marginal costs (MC) is given in figure 2.13.

Figure 2.13 Average cost curves



It is clear from figure 2.13 that fixed costs per unit decrease, but at a decreasing rate. The curves for the average variable costs and the average total costs are U-shaped, which indicates that these cost items decline, reach a minimum and then start to increase again. These cost curves (AΔC and ATC) decline as long as the marginal cost curve is lower, and the MC curve intersects the two curves at their lowest turning-points. A decision-making rule that emerges from the illustration, is that it is not rational to minimise marginal costs because its lowest turning-point falls within the irrational production zone I.

The preceding cost concepts can best be illustrated by means of a self-explanatory example, as explained in table 2.5. This example is not based on practical trial results, but illustrates an expected practical situation.

Table 2.5 Theoretical production costs of maize at different nitrogen levels, with all other inputs fixed

Yield per ha	Fixed costs	Variable costs	Total costs	Average fixed costs	Average variable costs	Average total costs	Marginal costs
1 t/ha	2 (R)	3 (R)	4=2+3 (R)	5=2÷1 (R)	6=3÷1 (R)	7=4÷1 (R)	$\frac{\Delta \textit{Total costs}}{\Delta \textit{Yield}}$ (R)
1,0	300	10	310	300	10	310	
2,5	30	30	330	120	12	132	13,3
4,2	50	50	350	71	12	83	11,8
5,4	70	70	370	56	13	69	16,7
6,3	90	90	390	48	14	62	22,2
7,0	110	110	410	43	16	59	28,6
7,4	130	130	430	41	18	58	50,0
7,6	150	150	450	40	20	59	100,0
7,7	170	170	470	39	22	61	200,0

Opportunity costs

Opportunity costs refer to the loss of revenue that occurs when an input was not used for the most profitable alternative. This indicates that every input on the farm has an alternative utilisation value (even if this means not using it at all) and that it should be used where it will make the biggest possible contribution to profitability.

When talking about profit, it usually refers to the gross income minus the total cost that was required to realise the income. *Opportunity* costs, however, add a new dimension since "unconcerned" costs also crop up. From this point of view it can be said that a branch is optimally profitable if the inputs (and more specifically the final unit input) could not be used more profitably anywhere else in the enterprise. An example of this is to use cultivated land for fodder crops instead of growing cash crops on such land. The cost of own roughage then equals the production cost of the fodder plus cash-crop income lost (or opportunity costs). Only if this is less than the cost of purchased roughage, is own fodder production a rational decision since it means that profit is maximised. Another example of opportunity costs is to use capital for the installation of a centre pivot rather than buying more land.

However, in many instances it is difficult to put a value on the loss of income.

For example, how does one determine what the financial contribution of a new shed, a new road or new boundary fences on a farm will be? It is nevertheless necessary to realise the fact that the alternative use of inputs holds financial implications for the enterprise and that they must be regarded as opportunity costs.

Benefits of scale

An aspect that evokes a lot of argument, is *benefits of scale*. It is also known as *economies of size*. In simple terms it means that bigger enterprises have advantages that are lacking in smaller ones. These advantages may be of a technical or economic nature.

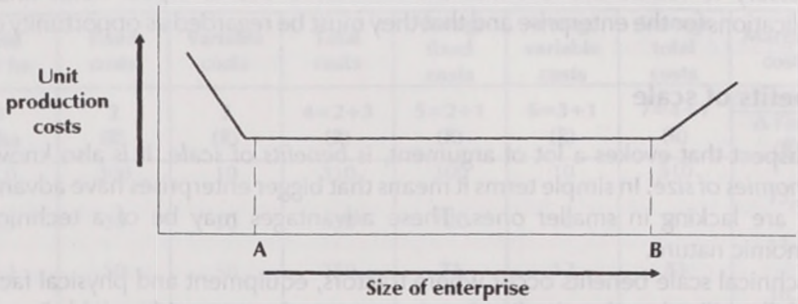
Technical scale benefits occur where tractors, equipment and physical facilities are fully utilised so that the fixed costs are spread over a wider yield. Economic benefits concern lower purchase prices of production inputs and higher selling prices of products. Large enterprises have greater bargaining power and can bargain for bigger discounts on bulk purchases. Although owners of smaller enterprises can co-ordinate their bargaining via agricultural cooperatives, it often happens that large enterprises can bargain for even better deals than cooperatives. Although there is much emphasis on the advantages of size, large enterprises also have scale drawbacks, and it is no simple matter to determine optimum enterprise size in practice.

According to studies and observations conducted in agriculture, it appears that there may be a wide range of optimum enterprise sizes within the same branch of production. This means that the unit cost per enterprise size decreases relatively fast and then maintains a low level, after which it gradually starts to rise. Graphically, it can be depicted as in figure 2.14.

According to figure 2.14 two wheat farms that lie on the same level (points A and B) will basically have the same benefits of scale even if the extent of one is, say, 500 ha and that of the other 1 500 ha. This is also the reason why it is found in practice that smaller farming enterprises can compete successfully with bigger ones.

Since scale advantage and disadvantages can occur in both large and small enterprises, it is difficult to empirically lay down the optimum farming enterprise size. Another reason for this is that it is very difficult to measure the management potential of the specific farmer. However, practical experience indicates that the yield per land area or animal unit declines if enterprises exceed a certain optimum size. It is nevertheless true that large farming units can survive setbacks more readily and generally have better financial results than smaller units despite their lower productivity. The reason for this can usually be found in the fact that the greater volume of production of large enterprises counteracts the loss of unit productivity. Many of the financial problems experienced by small farming units are not always

Figure 2.14 The influence of enterprise size on unit production costs



due to too low physical productivity, but rather to an unfavourable financial structure and the fact that the income in absolute terms is too low to maintain the farmer and his family. The productivity of the small unit may therefore be very good, but the total income too low. Farmers must be aware of this fact, and also of the potential cost savings brought about by bigger units.

SUMMARY

Agricultural production refers to the combination and transformation of production inputs into food, fibre, timber, liquor and tobacco. In this production process the farmer must make decisions on *what, how* and *how much* to produce.

To find logical answers to these three questions, the farmer uses certain production economic and cost principles. Of importance for agricultural production is knowledge of the typical production function in agriculture, the law of diminishing returns, marginalism, the optimum combination of production inputs and of products, and also certain cost concepts.

3

Farm Budgets: Auxiliary and Capital Budgets

OBJECTIVES

- **To define a budget and outline the importance of budgets in general.**
- **To express some views on determining the amount of inputs and input prices, and on determining output quantities and product prices for budgeting purposes.**
- **To identify the different types of farm budgets.**
- **To explain the meaning and use of branch (enterprise) budgets.**
- **To explain the meaning and use of partial budgets.**
- **To explain the meaning and use of break-even budgets.**
- **To explain the "time value of money" as well as the difference between the calculation of the future value of money (compound interest) and the present value of money (discounting).**
- **To explain the meaning and use of different capital budgeting techniques.**

A budget can be regarded as a written plan for future action, expressed in physical and financial terms. Since it concerns the future, this advance planning is based on projections, historic data, premises and experience. Since no-one can predict the future accurately, the value of a budget must not be over-estimated. It is no magic formula that will ensure that everything goes well and is for the best.

Farmers often allege that budgets, as a result of the inherent risk and uncertainties in farming, are subject to so many errors that budgeting is not worthwhile. The risk and uncertainties in agriculture cannot be denied, but they make the use of budgets even more important than would have been the case if the future could be predicted with any degree of accuracy.

The alternative for planning by means of budgets is decision-making on the basis of intuitive guesswork or by simply ignoring an existing problem. Should the latter option be exercised, a decision is nevertheless being taken, namely the decision to do nothing. If the decision is based on intuition, emotional, rather than rational considerations prevail.

Budgets are therefore an *essential aid* for any scientific farmer since they compel him to plan and to ensure that the various activities are co-ordinated. It also provides him with a means of better control in that he can see whether his activities are progressing according to expectations and, if not, to make timely adjustments and/or introduce counter-measures.

The usefulness of a budget depends virtually entirely on the correctness and realism with which the quantity and nature of the expected inputs, cost price of the inputs, expected yields (outputs) and prices of the yields included in the budget, were determined.

- *The quantity of inputs and the costs involved* can usually be determined fairly accurately. From his own experience, own records or using other available information (e.g. agricultural extension services and publications) a farmer can determine how many inputs are required for a specific branch of his enterprise. The prices of such inputs are available from dealers and once provision has been made for expected price increases, production costs can be estimated with a fair degree of accuracy.

- *Correct estimate of the yield and especially the prices of uncontrolled* (and sometimes controlled) *agricultural products* is, however, complicated by the fact that both elements are basically subject to substantial fluctuations. Here the farmer must allow himself to be led by the yield averages for his region over a number of representative years and by the average prices of the past, adjusted for future expectations. The best and most practical method to follow is to make three estimates, namely a pessimistic, normal and optimistic estimate. He can, for example, estimate his maize yields and prices for a future period as follows:

Basis	**Yield t/ha**	**Price (R/t)**	**Income (R/ha)**
Pessimistic	2,0	200	400,00
Normal	3,2	250	800,00
Optimistic	4,0	280	1 120,00

From the above the farmer can see that his minimum income should be R400 per ha. He should now work out his budget for the pessimistic and normal expectations. If his production costs exceed his expected normal income, he will either have to cut down on his costs per ton of maize produced by, for example, withdrawing low-potential lands from production or seek a profitable way to use his lands by budgeting for a different branch. Different combinations of optimistic/pessimistic estimates of prices/yields are possible in the case of the above example.

Established farmers often find it impractical and unprofitable to suddenly switch from one type of production branch to another. The inflexibility of agriculture sometimes means that on the whole it might pay the farmer to persevere with a less profitable branch rather than switch to another product with a higher profit potential. Farmers must refrain from pursuing short-term market and production trends since most agricultural products are subject to both good and bad times — price and yield-wise — over the long term.

There is a wide range of farm budgets. The following are the most important:
- Enterprise or branch budgets
- Partial budgets
- Break-even budgets
- Capital budgets
- The farming plan
- The total budget
- The financing budget

ENTERPRISE (BRANCH) BUDGETS

Branch budgets can assume different forms. Typically, however, they contain the estimated income and directly allocatable variable costs of a production branch (e.g. maize) on a per unit basis (e.g. ha). The difference between the estimated income and the directly allocatable variable costs is commonly known as the *gross margin* of the specific branch of production and represents the potential contribution of that branch of production to the fixed and non-directly allocatable variable costs and therefore also the ultimate profit of the farming enterprise.

Because the variable costs that are "directly allocatable" depend on the circumstances within each farming enterprise and because no two enterprises have identical circumstances, it is not advisable to draw conclusions purely on the grounds of a comparison between different farming enterprises' (estimated) gross margins. One must first establish which cost items were deducted from the (estimated) income to determine the gross margin, which is why the term *margin above specified costs* is often preferred to gross margin.

Branch budgets are of particular importance in the development of a farming plan and when drawing up a total and financing budget (see chapter 4).

Table 3.1 Branch budget for N. Farmer for the production of 1 ha maize*

Description	Unit	Price/Cost per unit	Quantity	Value
1 Gross production value	ton	214,00	2,00	428,00
2 Allocated costs				
• Pre-harvesting costs				
— Seed	kg	1,500	9,00	13,50
— 3.2.0(30)	kg	0,470	150,00	70,50
— L.A.N.(28)	kg	0,304	75,00	22,80
— Curaterr	kg	4,810	7,50	36,07
— Atrazine	litres	6,74	4,00	26,96
— Power machinery (fuel and repairs)	hours	7,70	5,18	39,88
— Implements (repairs and lubrication)	ha			7,97
— Power machines (labour)	hours	1,050	5,698	5,98
— Implements (labour)	hours	0,900	7,362	6,63
— Interest on working capital**	Rand	0,195	161,095	31,41
• Total pre-harvesting costs				
(per ha)				261,70
(per ton)				130,85
• Harvesting costs				
— Power machines (fuel and repairs)	hours	7,70	0,82	6,32
— Implements (repairs and lubrication)	ha			4,52
— Power machines (labour)	hours	1,05	0,903	0,95
— Implements (labour)	hours	0,90	0,903	0,81
• Total harvesting costs				
(per ha)				12,60
(per ton)				6,30
• Total allocated costs				
(per ha)				274,30
(per ton)				137,15
Gross margin (per ha)				153,70
(per ton)				76,85

* The information in the budget was obtained from the Directorate of Agricultural Production Economics, Department of Agriculture and Water Supply.

** Interest on working capital was calculated at 19,5% compound interest from the month in which an input is made to the month of harvesting. Normally it would be from the date on which a cost is incurred to the date of payment.

It can also be used as basis for a partial budget where the replacement of one branch by another is being considered (see p.55).

Depending on particular preferences and circumstances, branch budgets contain fewer or more details of the various cost items. As a general rule, however, more detail is preferable since it contributes to better planning and greater accuracy. The data in table 3.1 serves as an example of a branch budget.

From the information contained in the budget given in table 3.1,it appears that N. Farmer can expect, under the given circumstances, (a yield of 2,0 t/ha and a maize price of R214/t) a gross margin (margin above specified costs) of R153,70 per ha or R76,85 per ton. (The fictitious name, N. Farmer, is also used in further examples. With the exception of those in chapters 6 and 7, the figures quoted in the rest of the examples do not apply to the same farming enterprise.)

On the grounds of the preceding estimated pre-harvesting costs and adjustments to the harvesting costs (for different yields), N. Farmer can now estimate his gross margin at different maize prices and physical yields per hectare as illustrated in table 3.2.

Table 3.2 Estimated gross margins for maize per ha at different maize prices and physical yields

Maize price (R/t) / Physical yield (t/ha)	182,00	198,00	214,00	230,00	246,00
1,70	36,97	64,17	91,37	118,57	145,77
1,85	63,33	92,93	122,53	152,13	181,73
2,00	89,70	121,70	153,70	185,70	217,70
2,15	116,04	150,44	184,84	219,24	253,64
2,30	142,39	179,19	215,99	252,79	289,59

Source: Directorate of Agricultural Production Economics, Department of Agriculture and Water Supply.

To facilitate planning, a *calendar of activities* is often added to the branch budget (the particulars contained therein are in any case needed, in principle, for drawing up the branch budget). Table 3.3 serves as an example of such a calendar of activities.

Table 3.3 Calendar of activities for the production of 1 ha maize*

Month	Activity	Implement	Power machine	Hours per hectare: Implement	Power machine	Labour: Implement	Labour: Machine
Aug.	Harrow	Disk harrow	57 kw tractor	0,84	0,92	1,008	1,012
Sept.	Plough	3-furrow plough	"	1,89	2,08	2,292	2,288
Oct.	Harrow	One-way disk harrow	"	0,68	0,75	0,815	0,825
Nov.	Plant	Four-row planter	"	0,69	0,76	2,504	0,836
March	Cultivate	Coil-tine cultiv.	"	0,61	0,67	0,743	0,737
July	Combine	Combine, 2,0m	"	0,75	0,82	0,903	0,903
Total				—	6,00	8,265	6,601

* Processed from information supplied by the Directorate of Agricultural Production Economics, Department of Agriculture and Water Supply.

A proper calendar of activities enables a farmer to estimate his resource requirements in respect of implements, power machines and labour per branch. Such an estimate is an essential prerequisite for developing a farming plan (see chapter 4).

PARTIAL BUDGETS

Partial budgets are used to test the profitability of a planned change(s) on a section of the farming organisation. Partial budgets can therefore be regarded as a type of intermediate step between branch budgets (see p.49) and the farming plan (see chapter 4). It differs from the branch budget in that more than one branch can be included and from the farming plan in that it does not envisage total reorganisation of the enterprise.

A partial budget only includes those changes in costs and income that occur in the enterprise because of the envisaged change(s). Total costs and income of the enterprise is therefore not applicable and need not be known. As a result the partial budget shows the estimated increase or decrease in the profitability of the enterprise as a result of the envisaged change(s) by systematically answering the following questions concerning the envisaged change(s):

- What is the amount of the additional costs that will have to be incurred as a result of the change?

- What is the amount of income that will have to be forfeited to effect the change?
- What is the amount of costs that will be saved as a result of the change?
- What is the amount of additional income that will be derived from the change?

The basic form of a partial budget is as follows:

	R		R
Additional costs	a	Cost saving	d
Forfeited income	b	Additional income	e
Subtotal	(a+b)	Subtotal	(d+e)
Increase in profit	c	Decrease in profit	f
	a+b+c		d+e+f

The change in profitability is determined by the difference between the two subtotals. If subtotal (d+e) is bigger than subtotal (a+b), the *increase* in profitability as a result of the envisaged change = c[(d+e) - (a+b)]. If, however, subtotal (a+b) is bigger than subtotal (d+e), the *decrease* in profitability = f[(a+b) - (d+e)]. (The mere fact that an envisaged change increases profitability does not mean that it should be implemented forthwith — the availability of resources, the relationship between different branches of production, etc., must also be taken into account — see discussion in chapter 4.)

The following are typical farming circumstances under which a partial budget finds application:

- Where the expansion or scaling-down of a specific branch of production is being considered.
- Where an additional branch of production is being considered.
- Where the total or partial replacement of an existing branch of production by another, is under consideration.
- Where the partial replacement of labour by mechanical equipment is being considered (see also chapter 11).
- Where the relative profitability of owning farming equipment compared with contract leasing is under consideration.
- Where the relative profitability of the purchase of new as against used farming equipment is under consideration.

The procedure when using partial budgets can finally be explained by means of a few practical examples.

Example 1

N. Farmer produces 450 ha of maize annually, and has thus far had his crop combined on a contract basis at a cost of R38 per ha. He is now considering the purchase of a maize combine harvester. The cost price of the harvester is R72 000, its expected useful life ten years and his expected salvage value at the end of its useful life R7 200. The opportunity cost of capital is 12% per year, while insurance costs are estimated at R725 per year over the useful life of the combine. According to the local extension officer the variable costs for diesel, maintenance and repairs should come to about R15 per ha annually. N. Farmer has a reliable machine operator whom he is prepared to pay R3 per combined hectare. Is it, from a profit point of view, desirable to buy the maize combine harvester?

Partial budget

The purchase of a maize combine harvester to harvest 450 ha maize per year instead of contract combining at a cost of R38 per ha

(a)	*Additional cost per year*		(d)	*Cost saving*	
	Depreciation costs $\frac{72\ 000 - 7\ 200}{10}$	6 480		Contract combining (450 x 38)	17 100
	Interest costs $\frac{72\ 000 + 7\ 200}{2} \cdot 0{,}12$	4 752			
	Insurance & 3rd party	725			
	Subtotal	11 957			
	Diesel, maintenance, etc.	6 750			
	Cost of operator	1 350			
	Total	20 057			
(b)	*Forfeited income*	—	(e)	*Additional income*	—
(c)	*Increase in profit*	—	(f)	*Decrease in profit*	2 957
		R20 057			R20 057

Conclusion: The planned change, from a profit point of view, is detrimental since it will bring about a R2 957 drop in profit per year.

Example 2

At present N. Farmer only plants maize on 900 ha per year and he is now considering replacing 200 ha of maize with wheat. All the existing implements will be retained for the planned conversion, but it will be necessary to buy a new wheat planter. The cost price of a wheat planter is R10 000 and the expected salvage value after a useful life of ten years is R1 000, while the opportunity cost of capital is 12% per year.

N. Farmer presently combines his maize planting with his own combine harvester, but plans to have the wheat harvested on a contract basis at R18 per ha. Is the planned switch to wheat, from a profit point of view, desirable?

Partial budget

*The production of 700 ha maize and 200 ha wheat per year compared with the production of 900 ha maize per year**

(a) *Additional cost* (wheat)		(d) *Cost saving* (maize)	
Wheat planter		Seed	2 700
Depreciation costs		Fertiliser, etc.	31 266
$\frac{10\,000 - 1\,000}{10}$	900	Insurance	8 200
		Fuel, repairs, etc.	9 570
		Labour	2 522
		Harvest costs (only variable costs)	2 520
			56 778
Interest costs			
$\frac{10\,000 + 1\,000}{2} \cdot 0{,}12$	660		
Subtotal	1 560		
Wheat seed	3 600		
Fertiliser, etc.	23 880		
Insurance	7 668		
Fuel, repairs, etc.	14 944		
Labour	2 328		
Combining costs @ R18/ ha	3 600		
Total	57 580		
(b) *Forfeited income* (maize)	—	(e) *Additional income* (wheat)	
200 ha maize x 2t x R214	85 600	200 ha x 1,7t x R295	100 300
(c) *Increase in profit*	13 898	(f) *Decrease in profit*	—
	R157 078		R157 078
Conclusion: The planned replacement of 200 ha maize with 200 ha wheat is, from a profit point of view, advantageous.			

*The figures in the example are hypothetical and only serve to illustrate the method of partial budgeting.

BREAK-EVEN BUDGETS

The purpose of a break-even budget is to determine the critical point (expressed in physical or financial terms) at which a certain action in the enterprise will cover the total costs involved in the action. A farmer can, for example ask himself what size of production (in ha cultivated, number of dairy cows kept) is required to cover his total costs. He may also ask himself what the extent of his production must be before he will buy his own combine harvester.

The break-even principle is based on the fact that certain cost items tend to vary in relation to the size of production or sales (variable costs), while others tend to remain fairly constant (fixed costs). As already explained in chapter 2, fixed costs remain unchanged regardless of the extent of production, while variable costs are that portion of the total cost that varies according to the extent of production.

The break-even point, in units, can be determined as follows:

$$PX = F + VX$$

Where P = price per unit
F = total fixed costs
X = break-even point in ha, production units or yield
V = variable costs per unit.

In the above equation the total income (PX) must therefore break even with the sum of total fixed costs (F) and total variable costs (VX). If the extent of X has to be determined, it can be done as follows from —

$$PX = F + VX$$
$$F = X(P-V)$$
$$X = \frac{F}{P-V}$$

The application of break-even budgets can be explained by means of a few examples (see chapter 11 for a further example).

Example 3

According to the data in example 1, Farmer N wants to establish how many hectare of maize he has to cultivate to justify, from a profit point of view, the purchase of the maize combine harvester.

Annual fixed costs		
Depreciation costs	=	R6 480
Interest costs	=	R4 752
Insurance, etc.	=	R 725
Total	=	R11 957
Variable costs per ha	=	$R\frac{6\ 750 + 1\ 350}{450} = R18$
(See chapters 2 and 11 for an explanation of fixed and variable costs.)		
Contractor's costs:		R38 per ha
Break-even point:		$X = \frac{F}{P-V} = \frac{11\ 957}{(38-18)} = \frac{11\ 957}{20} = 597{,}85\ ha$

Conclusion: If N. Farmer plants more than 598 (600) ha of maize, the purchase of a maize combine will be justified from a profit point of view.

Example 4

N. Farmer has a farm with an arable area of 450 ha on which he wants to produce maize and grain sorghum in a ratio of 5:3. He has the following information:

- Estimated annual fixed costs on depreciation, interest payments, regular labour, etc. = R85 000
- Estimated maize price = R214 per ton
- Estimated grain sorghum price = R177 per ton
- Expected yield per ha:
  Maize = 2,8 ton
  Grain sorghum = 2,1 ton
- Estimated variable costs per ha:
  Maize = R240
  Grain sorghum = R280

N. Farmer wants to determine the following:

- The minimum area that he has to cultivate to cover his present fixed and variable costs; and
- The minimum area that he has to cultivate to show a surplus of R25 000 per year above his present fixed and variable costs — therefore to realise a farm profit of R25 000 (see chapter 6).

Calculation

Gross production value

5 ha maize	=	R(5 x 2,8 x214)	R2 996,00
3 ha grain sorghum	=	R(3 x 2,1 x 177)	R1 115,10

Average gross production value per arable ha

$$= R\left(\frac{2\,996,00 + 1\,115,10}{8}\right) \qquad R\ 513,89$$

Variable costs

5 ha maize	=	R(5 x 240)	R1 200,00
3 ha grain sorghum	=	R(3 x 280)	R 840,00

Average variable costs per arable ha

$$= R\left(\frac{1\,200 + 840}{8}\right) \qquad R\ 255,00$$

Break-even point in ha to cover costs

$$= \frac{85\,000}{513,89 - 255,00} = \frac{85\,000}{258,89} = 328,32\ ha$$

Conclusion 1: N. Farmer will have to cultivate 205,2 ha maize and 123,12 ha grain sorghum to cover all costs.

Break-even point in ha to realise a farm profit of R25 000 per year

$$= \frac{85\,000 + 25\,000}{258,89} = \frac{110\,000}{258,89} = 424,89\ ha$$

Conclusion 2: N. Farmer will have to cultivate 265,56 ha maize and 159,33 ha grain sorghum to realise an annual farm profit of R25 000.

CAPITAL BUDGETS

Decisions concerning the desirability of capital investment in fixed and movable assets such as land, fixed improvements, farm implements and breeding stock are some of the most important and most complex with which a farmer can be faced. Decisions of this nature normally have long-term implications in the sense that the capital is tied up in these assets for relatively long periods. Moreover, the acquisition of a capital asset demands immediate capital outlay, while the income or benefits from the investment in farming usually only accrues to the enterprise over a period of years.

Because the benefits depend on future events and the future cannot be predicted or estimated with any degree of accuracy, it is necessary to analyse alternative investment possibilities with the greatest care. Capital budgets — discussed in this paragraph — are techniques that can be used for this purpose. However, before proceeding to a discussion and an explanation of the different capital budgeting techniques, it is essential to first become aware of the *time value of money,* since this underlies the whole problem of capital investment in long-term projects.

A capital budget is a technique used to assess the desirability of a planned capital project or the relative profitability of alternative capital projects.

The time value of money

If a logical person is given the choice of whether he wants to receive a gift of R10 000 in cash today or in a year's time, what will he prefer? Naturally the R10 000 today. Why?

- It can be invested with the result that more than R10 000 will be available after a year.
- There is the risk that the person who wishes to make the gift will no longer wish to do so in a year's time, or may only give part of the money — there is therefore risk involved in waiting.
- From a utility point of view, there is a time preference for money — a person would prefer to use the money today rather than in a year's time. (Where this paragraph is concerned with capital investment, no further attention will be paid to this aspect.)

In general it can therefore be said that there is a connection between the time at which a person receives money and the value that he attaches to that money — the time value of money.

The time value of money can be approached from two angles, namely the *future value* of a sum of money that is invested today, and the *present value* of a sum of money that will become available in the future.

The future value

When calculating the future value of money, the point of departure is that an investment earns interest that will be reinvested at the end of each period (year), together with the original investment, for further periods. The future value of money therefore includes the original investment plus the interest earned, plus interest on the accumulated interest earned. To determine the future value of money, *compound interest* is taken into account according to the following basic formula:

F	=	$I(1+i)^n$		
F	=	future value		
Where	I		=	initial investment
	i		=	interest rate
	n		=	number of periods.

(For the purpose of discussing capital budgets, calculation of the future and current value of an annuity will not be taken into account.)

If a person should therefore invest R100 for six years today at an annual compound interest rate of 10%, the future value of the R100 after six years will be $100(1+0{,}10)^6$ or R177,16. Instead of using the formula — which may sometimes result in very cumbersome calculations — the use of interest tables is recommended (see the annexure, table 1.2).

n = 6; i = 10% = 1,7716 x 100= R177,16

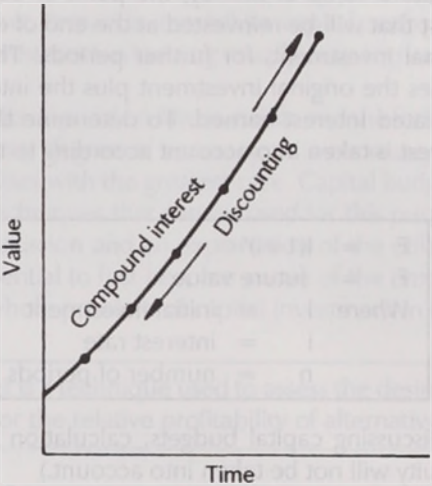
The present value

As already mentioned, the present value of money refers to the value that a specific sum of money that will be received in the future, has today. Present value is calculated by *discounting* the future sum. This discounting is done because the sum that will be received in the future will be worth less at present because of the time difference and assuming that interest rates will be positive.

The present value of a future sum of money can also be regarded as that sum of money that has to be invested at a given rate of interest now, so as to receive a sum of money equivalent to the future sum on the same date.

The calculation of compound interest is therefore the reverse process of discounting, and *vice versa*. Compound interest is calculated on a present sum to obtain its future value and a future sum is discounted to determine its present value. Figure 3.1 illustrates this relationship.

Figure 3.1 The relationship between compound interest and discounting



The present value of a future sum depends on the interest rate (discounting rate) and the period that elapses before the future sum is received. The higher the discounting rate and the longer the period, the lower the present value will be, and *vice versa*.

The following is the basic formula to determine *present value*:

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

Where P = present value
F = future sum
i = discounting rate
n = number of periods.

Suppose a person expects to receive R177,16 after six years. What will the present value be if he decides to discount it at 10% per year? Put differently, how much must a person invest today at a compound interest rate of 10% per year if he wants to have R177,16 after six years?

$$177{,}16 \cdot \frac{1}{(1 + 0{,}10)^6}$$

$$= 177{,}16 \cdot \frac{1}{1{,}7716}$$

$$= R100{,}00$$

As was the case when the future value of money was determined, the use of the formula for determing the present value of money can result in cumbersome calculations and the use of interest tables is recommended (see annexure, table 2.2).

n = 6;i = 10% = 0,5645 x 177,16 = R100,00

Capital budgeting techniques

In the farming context, three capital budgeting techniques have found particular favour:

- The payback period
- The rate of return
- The discounted cash-flow or net present value.

Because the discounted cash-flow technique has the most merit from a scientific point of view, it will be analysed in detail. The payback period and the rate of return techniques will only be dealt with in brief.

The following simplified example is used to illustrate the application of the three different techniques.

Example 5

Say N. Farmer is considering the following two capital projects:

	Project A	Project B
Cost (capital outlay)*	25 000	25 000
Salvage value*	—	—
Net cash flow after tax*		
Year 1	8 000	1 000
Year 2	8 000	2 000
Year 3	8 000	10 000
Year 4	8 000	12 000
Year 5	8 000	20 000
Total	R 40 000	R 45 000
Average	8 000	9 000

Question: Which project is the more profitable?

* See later discussion for an explanation of these concepts.

The payback period

> The payback period is the number of years which it takes a capital project to repay the capital investment in the project from its net cash income (cash flow) after tax.

Farmers often make the following remark: "This or that asset is a good buy because it pays for itself over so many or so many years." The regularity with which this remark is made shows how many farmers — consciously or unconsciously — use the payback period technique when deciding on capital projects.

If the expected net cash flow is constant every year, the payback period is determined according to the following formula

$$P = \frac{I}{C}$$

Where P = payback period
I = capital investment
C = average annual net cash flow after tax.

However, if the net annual cash flow is not constant, the annual net cash flow is added from year 1 until the amount is found where the total of the accumulating cash flow equals the investment.

The project with the shortest payback period is then regarded as the more advantageous, as is evident from the following:

Project A: $P = \frac{25\,000}{8\,000}$
$= 3{,}1$ years

Project B: $= \left(\frac{\textit{Year 1}}{1\,000} + \frac{\textit{Year 2}}{2\,000} + \frac{\textit{Year 3}}{10\,000} + \frac{\textit{Year 4}}{12\,000} = 25\,000\right)$
$= 4$ years

Answer: Project A is the more advantageous since it has the shortest payback period.

Although it is easy to determine the payback period and the technique *does* identify the project with the fastest net cash inflow, the technique has *serious shortcomings* as a criterion of profitability:

- The payback period does not take into account the economic life of the project or the net cash flow after the payback period. It rather serves as a criterion of liquidity since it indicates how soon the capital investment will be recovered.

- The payback period does not take into account the point of time of the cash flow and therefore totally ignores the time value of money.

The rate of return

> The rate of return is the average annual net cash flow after tax,minus the average annual depreciation expressed as a percentage of the capital investment.

The rate of return of a project can be determined according to the formula:

$$R = \frac{C - D}{I}$$

Where R = rate of return
C = average annual net cash flow after tax
D = average annual depreciation
I = capital investment.

The rate of return of the two alternative projects under consideration is then as follows:

Project A:
$$R = \frac{8\,000 - (\frac{25\,000 - 0}{5})}{25\,000} = \frac{3\,000}{25\,000} = 0{,}12 \text{ or } 12 \text{ percent}$$

Project B:
$$R = \frac{9\,000 - (\frac{25\,000 - 0}{5})}{25\,000} = \frac{4\,000}{25\,000} = 0{,}16 \text{ or } 16 \text{ percent}$$

Answer: Project B is the more profitable.

The rate of return technique has the advantage over the payback period technique in that it takes the income over the entire life of the project into account, but it still does not take the point of time of the cash flow — and therefore the time value of money — into account. The result is that the use of this technique to choose between projects could lead to erroneous investment decisions.

Even if the net cash flow of project A should, for example, be

$$\frac{Year\ 1}{20\,000} + \frac{Year\ 2}{12\,000} + \frac{Year\ 3}{4\,000} + \frac{Year\ 4}{2\,000} + \frac{Year\ 5}{2\,000} = 40\,000,$$

the rate of return is still 12%.

In essence there is little difference between a partial budget (discussed earlier in this chapter) and the rate of return technique, and the former can also be used in the judging of planned capital projects or investment decisions. (See also the discussion in chapter 11 on investment in farm implements.) As a technique for capital budgeting, however, partial budgets have the same drawbacks as the rate of return technique.

The net present value

> The net present value takes the time value of money and the opportunity cost of investment in capital projects into consideration and as such is a better criterion for judging the profitability of capital projects than either the payback period or the rate of return.

Use of the net present value technique calls for the following steps to be taken:

- Decide on a discounting rate.
- Calculate the present value of the cash outlay to launch the capital project(s) or to purchase the asset(s).
- Calculate the annual net cash flow of the project(s) over its (their) life.
- Calculate the present value of the annual net cash flow.
- Calculate the net present value of the project(s).
- Accept or reject the projects or choose the most advantageous one.

Step 1: The discounting rate

The discounting rate is used to adjust the expected future net cash flow to its present value. The discounting rate chosen represents the minimum acceptable rate of return for a capital project, which makes the choice of the "correct" discounting rate vitally important.

There are different approaches to the choice of a discounting rate. The following three are the most commonly used:

- The after-tax cost of capital.
- The after-tax cost of loan capital.
- The after-tax opportunity cost of own capital (return on own capital — see

chapter 7).

For capital budgeting purposes, the cost-of-capital approach is preferred, while the other two approaches can be followed to determine the discounting rate when analysing the desirability of alternative financing methods in the purchase of capital assets — see the discussion in chapter 11.

If the cost-of-capital approach is followed, the applicable formula for determining the discounting rate is the following:

$$D = reGe + Ks(1-t)Gs$$

Where
- D = discounting rate
- re = after-tax opportunity cost of own capital (after-tax rate of return on own capital)
- Ge = the percentage own capital used in the enterprise
- Ks = the weighted cost (interest rate) of loan capital used in the enterprise
- t = the marginal tax rate applicable to the enterprise
- Gs = the percentage loan capital (debt) used in the enterprise.

The cost-of-capital approach takes the view that any capital project should at least compensate the farmer for the cost of the capital invested. Over the long term the vast majority of farming enterprises use own and loan capital to acquire capital assets and the cost of capital should be based on the combination of own and loan capital which the farmer deems necessary for use in his enterprise in the foreseeable future. It must therefore be based on the optimum capital structure for the foreseeable future (see the discussion of an enterprise's financing policy in chapter 8) and not on the combination of own and loan capital that will be used for financing the planned capital project and also not necessarily on the present combination of own and loan capital used in the enterprise. The farmer could use his balance sheet to determine the ratio between own and loan capital and between the various types (forms) of loan capital (see the discussion on the farm balance sheet in chapter 6), but if the present combination differs, for some reason or another, from that which he deems desirable for the foreseeable future, the necessary adjustments should be made to the capital composition before the discounting rate is calculated.

A few aspects concerning the capital cost approach to the determination of the discounting rate should be emphasised:

- In essence this approach reflects the manner of financing the capital project over the long term, and the tax implications of interest payments on loan capital. When calculating the cash outlay required for a specific project (step 2) it is therefore unnecessary to take the manner or source of financing into consideration.
- The *market-related* interest rates and the return on own capital are used to determine the discounting rate. These market-related rates reflect the expectations of those who participate in the market, about the inflation rate for the entire national economy. As a result the expected inflation concerning price and cost increases must also be taken into account when calculating the net cash flow (step 3).
- If a farmer uses only own capital for financing or plans to use only own capital in the foreseeable future, the discounting rate will naturally be the after-tax rate of return on own capital.

Finally, a numerical example to illustrate the calculation of the discounting rate.

Example 6
Suppose N. Farmer has the following information and wants to calculate the rate at which he must discount the net cash flow of a planned capital project:

Capital structure	= 80% own capital and 20% loan capital
Composition of loan capital	= 40% short-term, 30% medium-term and 30% long-term capital
Present interest rates	= 19,16 and 12% per year on short, medium and long-term loan capital respectively
∴ Weighted cost of loan capital	= (0,40 x 0,19) + (0,30 x 0,16) + (0,30 x 0,12)
	= 0,16 or 16%
After-tax rate of return on own capital	= 12%
Marginal tax rate	= 25%
∴ Discounting rate	= (0,12 x 0,80) + 0,16(1-0,25) · 0,20
	= (0,12 x 0,80) + (0,16 x 0,75 x 0,20)
	= 0,096 + 0,024
	= 0,12 or 12%

Step 2: The present value of the cash outlay
In most capital projects the present value of the cash outlay will be equal to the cash cost price of the asset plus GST. There may, however, be instances where an additional capital layout is desired in future years to replace obsolete equipment, or to purchase additional equipment that may be required. In such situations the

future capital outlay must be discounted to its present value.

It is also essential to take the total capital outlay that may be required into account when assessing the project. For example, the purchase and cultivation of an additional piece of land may also demand additional current and movable assets (implements) and this extra capital outlay must also be considered — at its present value as part of the present outlay of the project. Note that what is concerned here is the present value of additional capital outlays, not capital repayments on loans that were negotiated to finance the project. This latter is not taken into account since the combination of own and loan capital was taken into account when the discounting rate was determined.

Step 3: The annual net cash flow or income

The annual net cash flow here is the annual *after-tax* difference between the cash income and cash expenditure from the project concerned and must be estimated for the entire life of the project. Only cash income and expenditure are taken into account here — depreciation is not directly involved in the calculations. Depending on the tax legislation involved, it could, however, affect the annual income tax payable and in this sense depreciation does play a role in calculating the annual net cash flow after tax.

In the normal course of things the cash income from a project will consist of product sales (amount x price) and the cash expenditure for input costs (amount x price). When estimating prices in respect of future years, inflation must be taken into account. Interest on loan capital that may be used to finance the project and the tax implications thereof are not regarded as part of the cash expenditure because this has already been provided for in the discounting rate. The expected salvage value of the project (or part thereof) at the end of its useful life, is regarded — in the year in which it is sold or traded in — as part of the cash income (cash inflow). Do not lose sight of the tax implications.

Step 4: The present value of the annual net cash flow

The present value of the annual net cash flow is obtained by multiplying the net cash flow for a specific year by the *discounting factor* for that year. (Discounting factors for different periods (n) at different discounting factors (i) are given in the annexure, table 2, e.g. n= 6; i = 10; discounting factor = 0,5645.)

The total net cash flow of a planned project(s) is obtained by adding together the present values of the different years' net cash flow.

Table 3.4 Present value of the net cash flow of projects A and B at a 12% discounting rate

Year	Project A			Project B		
	Net cash flow	Discounting factor	Present value	Net cash flow	Discounting factor	Present value
1	8 000	0,8929	7 143	1 000	0,8929	893
2	8 000	0,7972	6 378	2 000	0,7972	1 594
3	8 000	0,7118	5 694	10 000	0,7118	7 118
4	8 000	0,6355	5 084	12 000	0,6355	7 626
5	8 000	0,5674	4 539	20 000	0,5674	11 348
Total	R40 000		R28 838	R45 000		R28 579

Step 5: The net present value of the project(s)

The net present value is simply the present value of the total net cash flow of a project or projects *minus* the present value of the cash outlay to purchase (erect) the project(s).

The net present value of project A is therefore R3 838(R28 838 - R25 000) and that of project B R3 579 (R28 579 - R25 000).

Step 6: Accept/reject the project(s) or choose the most advantageous project(s)

The criteria for accepting/rejecting a project are simple. If the project has a positive net present value, it is acceptable, and *vice versa*, and the project with the biggest net present value is the most profitable. In the example project A is therefore more profitable than project B, although both are acceptable.

The cost of capital was taken as the discounting rate and a positive net present value indicates that the investment (project) yields more than the cost of capital (the cost of own and loan capital)to finance the project. The bigger the net present value of the project, the bigger this favourable difference between project yield and cost. The following two further aspects concerning the desirability of capital projects deserve attention:

THE FINANCIAL FEASIBILITY OF THE PROJECT

The net present value of a capital project is a measure of the profitability of a project over its life. It is, however, possible that a specific project may show a negative cash flow for many years, depending on the pattern of the cash income from it and the financing method. This statement can be explained from the preceding example of projects A and B. Suppose both projects are fully financed by means of an instalment sales agreement over a period of five years at an effective interest rate of 16% per year, and that the debt is repayable in equal annual instalments (see also the explanation of the instalment sales agreements in chapters 6 and 11).

Year	Project A			Project B		
	Net cash flow	Instalment R25 000 @ 16% for 5 years*	Cash difference	Net cash flow	Instalment R25 000 @ 16% for 5 years*	Cash difference
1	8 000	**4 341	3 659	1 000	**4 341	-3 341
2	8 000	7 365	365	2 000	7 365	-5 635
3	8 000	7 365	365	10 000	7 365	2 365
4	8 000	7 365	365	12 000	7 365	4 365
5	8 000	7 365	365	20 000	7 365	12 365

* See annexure, table 3.4; n= 5; i = 16; R25 000 x 0,3054 = R7 635 per year.

** The annual instalment comes to R7 635. Since the total interest (R13 175) is a valid tax deduction in the first year (1985/86), there is, at a 25% marginal tax rate, a tax saving of R3 294 and the effective cash outflow is therefore only R4 341.

Although both projects A and B shows positive net present values and both are therefore acceptable from an investment point of view, project B, under the given circumstances, displays substantial cash deficits and if N. Farmer wants to launch the project, his cash flow from the present total enterprise will have to be such that it can carry this deficit. If not, alternative financing methods will have to be considered. The mere fact that a project shows a positive net present value and can therefore be regarded as desirable from an investment point of view, does not necessarily mean that the project can be launched. A final decision on this only becomes possible once it has been established that the project, from a financing point of view, is feasible. The investment decision (capital budget) can therefore be clearly distinguished from the financing decision (financing budget — see chapter 4) and the choice of the most profitable financing method (see chapter 11).

> In capital budgeting a clear distinction must be made between the investment decision and the financing decision.

RISK AND UNCERTAINTY

Because capital budgets often cover a very long period, they are probably more prone to errors than any other budget. Changes in price and demand and in the inflation rate could, for example, mean that the actual results from a project differ drastically from what the budget made provision for. This possibility does not, however, mean that a farmer should not budget (plan); it only means that he should try and make provision for such circumstances in his budget, wherever possible.

This can be done in one of two ways:

- Adjust the discounting rate according to the risk sensitivity of the planned projects. The net cash flow of projects with higher risk is discounted at higher rates. If this is done the discounting rate based on the cost of capital will represent the minimum rate at which "safe" projects are judged.
- Discount the net cash flow budgeted for later years at higher discounting rates than those used in the initial years or year. Once again the discounting rate based on the cost of capital will represent the minimin rate for the initial year or years.

SUMMARY

A comprehensive system of farm budgets is a scientific planning and control aid. As a minimum requirement a farmer should have a farming plan, a total and a financing budget. In the development and adjustment of these budgets the management-orientated farmer should use auxiliary budgets in the form of branch, partial, break-even and capital budgets.

In this chapter attention was paid to the meaning and use of auxiliary budgets. Chapter 4 will deal with the farming plan, total budget and the financing budget.