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BEEF PRODUCTION SYSTEMS FOR THE NORTH-WESTERN TRANSVAAL SWEET BUSHVELD : A SIMULATION MODEL*

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1. THE PROBLEM

The optimum beef production system and selling practice depends on the degree of risk and the locality where it takes place. The effect of veld control and herd management, including selection practices, is reflected in financial results in the course of time. Management in beef cattle production, particularly in the hotter cattle grazing regions, is complicated by fluctuations in the quantity and quality of fodder supplied by the natural grazing. This creates a substantial problem for the entrepreneur who must decide on a production system that will have the greatest physical and economic advantage and stability in the long term.

The long-term economic result in large stock farming involves the average expected income and fluctuations in it. Varying climatic conditions cause fluctuations in production possibilities between years and seasons. Market conditions are affected in that disposal of stock and withholding for growth and/or breeding alternate as feeding conditions on the veld change. Herd performance is influenced to a very great extent by feeding. Rainfall, temperature, soil type and stocking are determining factors of grazing and therefore feeding conditions. Various production systems differ inherently in respect of potential profits and their stability.

2. THEORETICAL PRODUCTION MODEL

Beef cattle production may be represented by a mathematical model. Such a model can be useful for comparing production systems. Assume that:

PP	=	physical production in kilograms
MIC	=	mass increase for calves
CB	=	calves born
WM	=	average weaning mass of calves
MIO	=	total mass increase for older cattle
NO	=	number of older animals at beginning of year
NOC	=	number of cows
NOH	=	number of heifers
NOT	=	number of steers
NOO	=	number of oxen
AM	=	average mass increase of older animals
PW	=	post-weaning growth to one year
P	=	purchases
S	=	sales
AMS	=	average mass at sale
AMP	=	average mass at purchase
AS	=	average stocking (total starting mass)

The letter "t" indicates the situation in the present period or year "t-l" the previous period and "t+l" the end of the present or beginning of the following period.

Physical production may be expressed in terms of:

$$PP_t = MIC_t + MIO_t$$

with

$$MIC_t = CB_t \cdot WM_t$$

and

$$MIO_t = NO_t \cdot AM_t$$

Therefore

$$PP_t = CB_t \cdot WM_t + NO_t \cdot AM_t$$

The number of older animals (NO_t) consists of:

$$NO_t = NOC_t + NOH_t + NOT_t + NOO_t$$

of which the total mass increase of (NO_t) at the end of the year may be expressed as:

* Based on an M.Sc.(Agric.) thesis by A. Louw, University of Pretoria.

$$NO_{t+1} \cdot AM_t = NOC_t \cdot AM_{ct} + NOH_t \cdot AM_{ht} + NOT_t \cdot AM_{st} + NOO_t \cdot AM_{ot}$$

$$PP_t = CB_t \cdot WM_t + NOC_t \cdot AM_{ct} + \dots\dots\dots + NOO_t \cdot AM_{ot}$$

where the letters c, h, s and o appearing before t represent cows, heifers, steers and oxen, respectively.

Similarly CB and AM are factors that are influenced by various other circumstances.

So $CB_t = f\ (year_t,\ year_{t-1},\ NOC_t,\ NO_t)$

$\approx f\ (year_t,\ year_{t-1},\ NOC_t,\ AS_t)$

Similarly is $CB_{t-1} \approx f\ (year_{t-1},\ year_{t-2},\ NOC_{t-1},\ AS_{t-1})$

At the same time weaning mass is (WM_t)

$WM_t = f\ (year_t,\ season_t,\ AS_t,\ CB_t,\ P_t,\ S_t)$

and $AM_t = f\ (WM_t)$

The average mass increase

$AM_t = f\ (year_t,\ AS_t,\ CB_t,\ P_t,\ S_t)$

The number of older animals (NO_t) is, however, dependent on the previous year's performance, sales and purchases:

$$NO_t = NO_{t-1} + CB_{t-1} - S_{t-1} + P_{t-1}$$

and similarly the number of older animals at the beginning of the previous year is NO_{t-1}:

$$NO_{t-1} = NO_{t-2} + CB_{t-2} + P_{t-2} - S_{t-2}$$

and

$$NO_{t+1} = NO_t + CB_t + P_t - S_t$$

By carrying forward S_t sales in the present period appear to be dependent on purchases, sales and fertility over at least two years:

$$S_t = NO_t + CB_t + P_t - NO_{t+1}$$

$$= NO_{t-1} - S_{t-1} + P_{t-1} + CB_{t-1} + CB_t - NO_{t+1}$$

P_t is therefore an annual commercial production that is subtracted from the herd. The factors that determine the subtraction, however, depend on certain other factors. If the scope of this dependence can be determined and expressed quantitatively, it will be possible to facilitate the entrepreneur's decision making.

$$S_t = f\ (year_t,\ year_{t-1},\ S_{t-1},\ CB_t,\ CB_{t-1})$$

and

$$S_{t-1} = f\ (year_{t-1},\ year_{t-2},\ S_{t-2},\ CB_{t-1},\ CB_{t-2})$$

Depending on conditions in this particular year, sales are influenced by the number of animals available for sale and by the pressure to sell, that is to say climatic and grazing conditions in a particular year. The number of older animals in a particular year is

$$NO_t = f\ (year_{t-1},\ CB_{t-1},\ S_{t-1},\ P_{t-1})$$

and

$$NO_{t-1} = f\ (year_{t-2},\ CB_{t-2},\ S_{t-2},\ P_{t-1})$$

It is therefore not only the climatic conditions in both the present and the previous year that influence the number of older animals available at present, but also the number of calves born and sales and purchases the previous year.

There therefore appears to be a functional relationship between sales and years. They are also interdependent. This is also the case with the purchases between years. The effect of purchases and sales in the present as well as the previous year and the number of calves born and the mass increases of both calves and older animals are reflected in the physical production and therefore in the functional efficiency of the herd, veld and management. Annual sales indicate mainly commercial production. The importance of the number of calves born, mass increases, climate and stocking therefore cannot be over-emphasised because they influence not only production at the present stage, but also production in the following period.

3. FACTORS THAT INFLUENCE PRODUCTION SYSTEM RESULTS

In an area that is subject to fluctuating climatic conditions and where grazing production varies between seasons, herd composition and consequently the production system followed play an important part. The results of the different production systems are influenced by a number of factors, such as the following:

1. Capital investment per LSU
2. General cost structure
3. Purchase and selling prices of various classes of cattle
4. Herd performance, i.e. calving percentage, weaning weight and post-weaning growth rate
5. Occurrence of rainfall and droughts
6. Inherent genetic characteristics of herds
7. Marketing age
8. General managerial skill

In any specific beef cattle production system the herd composition and turnover are influenced by calving percentage and marketing age. If marketing is done at an early age, the percentage of cows in the herd is high; a low calving percentage also means that more cows are needed to keep stock numbers in agreement with the grazing potential.

The degree of flexibility that is desirable in a beef cattle production system increases as variability in weather and grazing conditions increases. In a region such as the North-Western Transvaal Sweet Bushveld a considerable degree of flexibility is essential.[1] In a flexible system stock numbers can reasonably be reduced or increased to suit the varying veld production. Flexibility therefore involves keeping a relatively high number of oxen and a relatively low percentage of breeding stock. This gives flexibility, particularly in respect of marketing ages and therefore the stocking or clearing of the veld. The expansion and reduction of a herd takes place without, in the case of clearing, disposing of good breeding stock.

Coetzee[2] found that farmers in the sweet bushveld tend to keep too high percentages of breeding animals in the herds; consequently when drought conditions require a considerable reduction in stock numbers the necessary clearing cannot take place without disrupting the breeding programme and losing good breeding material. In addition, it is difficult to sell breeding animals during periods of drought at acceptable prices. The percentage of breeding animals in the herd must therefore depend on the extent to which veld production fluctuates in the long term.

One problem with expansion or reduction phases in a system is that they are accompanied by respectively high and low stock prices because sales take place at lower prices during droughts and feeding costs are high then.

In prosperous times purchase prices are higher and feed costs relatively lower. In more stable areas the optimum marketing ages will consequently be lower and also more uniform than in more changeable regions.

Before capital is invested in a specific production system it is essential to compare different alternative returns to invested capital. In beef production system comparisons there is the problem that production cycles of different lengths are found. Some produce a faster turnover than others and therefore the time pattern of the profit is important. A method[3] that may be used to compare cash profits of different dates in the future is to discount them to the starting point and compare them. The rate at which they are discounted will be the compound interest that the investment could have earned elsewhere. The incidental costs can be estimated this way. This method is known as the discounted cash flow method. The entrepreneur can therefore choose a specific system that will give him a greater profit than comparable systems for a considerable time. The full investment in land, stock, buildings, feed and medicines and also labour requirements can be taken into account.

Flexibility in a production system is achieved at a cost, through which a more certain, lower income is chosen over an uncertain higher income, depending on the managerial skill of the entrepreneur and the degree to which he is prepared to take risks.

According to Gray[4] the average cost per unit of mass produced in a non-flexible production system, under normal weather conditions is lower than in a flexible system. An entrepreneur who farms as though no droughts occur has lower costs. If a drought does occur, the flexible production system will have relatively lower costs per mass unit produced because it was prepared for it.

4. A SIMULATION MODEL FOR SYSTEM COMPARISON

4.1 The model

A simulation model was built to evaluate the long-term results of seven synthesised beef cattle production systems on natural grazing in the North-Western Transvaal Sweet Bushveld. In this article the results of four of these systems will be shown.* Actual rainfall figures were used to simulate potential results, although with modern technology available, for each year over a fifty year period. Such a long period should be enough to include most variations in climate. The simulation results cannot be regarded as representative of the whole North-Western Transvaal Sweet Bushveld, as will appear from the assumptions. Nevertheless they will illustrate certain principles. In addition, the technique can serve as a guideline for future research.

Simulation in stock farming and decision making has been undertaken by Halter and other researchers,[5] among others. In an ecosystem model designed by Goodall[6] extensive grazing systems for sheep were simulated in the long term and optimum grazing intensities determined in the light of a specific management objective. It took into account the effect of stocking, composition of species, soil moisture, occurrence of droughts and numerous other variables.

For the purpose of the simulation model the rainfall was divided into three categories:

(i) Less than 300 millimetres
(ii) Between 300 and 425 millimetres
(iii) Over 425 millimetres

The rainfall data in respect of one specific farm were used for this purpose.

For each production system different deciding rules applied regarding sales in each rainfall category. This deciding rule is also influenced by the status of the system, which in turn is influenced by the previous year's decisions. Different average net selling prices were assumed for the different rainfall categories, namely (per kilogram live mass):

(i) Below 300 millimetres = 35 cents per kilogram
(ii) Between 300 and 425 millimetres = 40 cents per kilogram
(iii) Over 425 millimetres = 45 cents per kilogram.

The following functional relationships between certain production and natural phenomena were used:

$$Y_1 = 91{,}328 - 0{,}645X_1 \tag{1}$$
$$Y_2 = 216{,}99 + 0{,}0394X_2 - 4{,}2338X_1 \tag{2}$$
$$Y_3 = 116{,}465 + 0{,}5915X_3 + 0{,}177X_2 \tag{3}$$
$$Y_4 = 260{,}854 + 0{,}1463X_2 \tag{4}$$
$$Y_5 = 1{,}25Y_3 \tag{5}$$
$$Y_6 = 1{,}333Y_5 \tag{6}$$
$$Y_7 = 1{,}375Y_4 \tag{7}$$
$$Y_8 = 1{,}333Y_7 \tag{8}$$

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* Results of the other three systems appear in Louw, A. (1975). *Wisseling in die finansiële resultate van beesboerdery in die Noordwes-Transvaalse Soetbosveld.* M.Sc.(Agric.) thesis, University of Pretoria.

when

Y_1 = calving percentage
Y_2 = weaner mass (kg)
Y_3 = mass of 18 month old heifers
Y_4 = mass of 18 month old steers
Y_5 = mass of 24 month old heifers
Y_6 = mass of cows
Y_7 = mass of oxen between 24 and 27 months old
Y_8 = mass of oxen between 39 and 42 months old
X_1 = stocking in present year in kilograms per hectare
X_2 = rainfall in present year in millimetres
X_3 = weaning mass of heifers = Y_2

The first four comparisons derived from regression analyses by Louw,[7] and for purposes of comparisons (5) to (8) constant mass ratios between different ages are assumed.

The average income over 53 years, the standard deviation from it and the coefficient of variation were calculated for each of the production systems.

Figure 1 shows a flow diagram for the model.

4.2 Assumptions

The model was further based on a number of assumptions:

1. Production is entirely dependent on the natural grazing, which covers 2 000 hectares.
2. Herd management is at a high level and the cattle have a relatively high genetic potential, which is kept high by judicious selection.
3. Replacement rate of cows is 20 per cent : 15 per cent for age between nine and 10 years and five per cent for performance.
4. Annually at least 20 per cent of calves and heifers are retained for replacement.
5. The cow-bull ratio varies between 20 and 25 to 1.
6. There is only one mating season annually from 15 January to 15 March.
7. Variable costs amount to R20 per LSU or 4,4 cents per kilogram per year.
8. Although purchases were not brought into the model, they are nevertheless possible. Although it is not entirely realistic, it was assumed that prices of bulls purchased and sold cancel each other out.
9. It is also assumed on the basis of a survey that 27,7 per cent of the total stock on the farm consists of dairy and working cattle, goats and sheep, and game (impala, kudu, waterbuck, warthogs).

4.3 Description and decision rules of simulated production systems

Weaner production system I (system 1)

All bull weaners are sold and at least as many heifer calves as cows being replaced must be retained, regardless of the rainfall. Annually 20 per cent of the cows and all large and 18 month old heifers not used for replacement are culled and sold. A simple sales strategy is therefore followed. It is a non-flexible production system.

Steer system (18 months old) (system 2)

When rainfall is less than 300 millimetres all bull calves and steers are sold. If it follows a poor rainfall of 300 millimetres, only bull calves are available for sale. At least 20 bull calves, however, must be retained for further production practices. All heifer calves and 18 month old heifers except replacement heifers are also sold. If rainfall is between 300 and 425 millimetres and the previous year's rainfall was below 300 millimetres, no steers will be available for sale and all bull calves (except 20) can be sold. If a rainfall of between 300 and 425 millimetres or one of more than 425 millimetres occurs and they follow one another, there will be steers available for sale. Only steers and culled cows and heifers are then sold.

26-28 month ox production system (system 3)

If rainfall is less than 30 millimetres for two successive years, all oxen, steers and bull calves and also all heifer calves and 18 month old heifers (except replacement heifers) and culled cows are sold. If a rainfall of less than 300 millimetres follows a rainfall of between 300 and 425 millimetres, the same sales pattern is followed.

Where a rainfall of between 300 and 425 millimetres follows a rainfall of less than 300 millimetres only culled cows and heifers are sold. If this follows a rainfall of between 300 and 425 millimetres, both steers and oxen are sold as well as culled cows and heifers. If it follows a rainfall of over 425 millimetres, all 26-28 month oxen and culled heifers and cows are sold.

In the case of a rainfall of over 425 millimetres following a rainfall of less than 300 millimetres no steers or oxen are available for sale. Only culled cows and available culled heifers are available for sale. If it follows a rainfall of first less than 300 millimetres and then between 300 and 425 millimetres, still no oxen will be available for sale. If the rainfall of between 300 and 425 millimetres follows a rainfall of over 425 millimetres oxen will be sold.

So where a rainfall of over 425 millimetres occurs all 26-28 month oxen are sold and normal culling and sales practices are followed for cows and heifers.

39-42 month ox production system I (system 4)

Where rainfalls of less than 300 millimetres occur in succession all oxen, steers, large heifers, 18 month heifers and heifer calves (except those for replacement) and culled cows are sold. If this follows a rainfall of between 300 and 425 or even over 425 millimetres, the same sales take place. No bull calves are sold in years with a rainfall of less than 300 millimetres.

In the case of a rainfall of between 300 and 425 millimetres that follows a rainfall of less than 300 millimetres only culled cows and heifers are

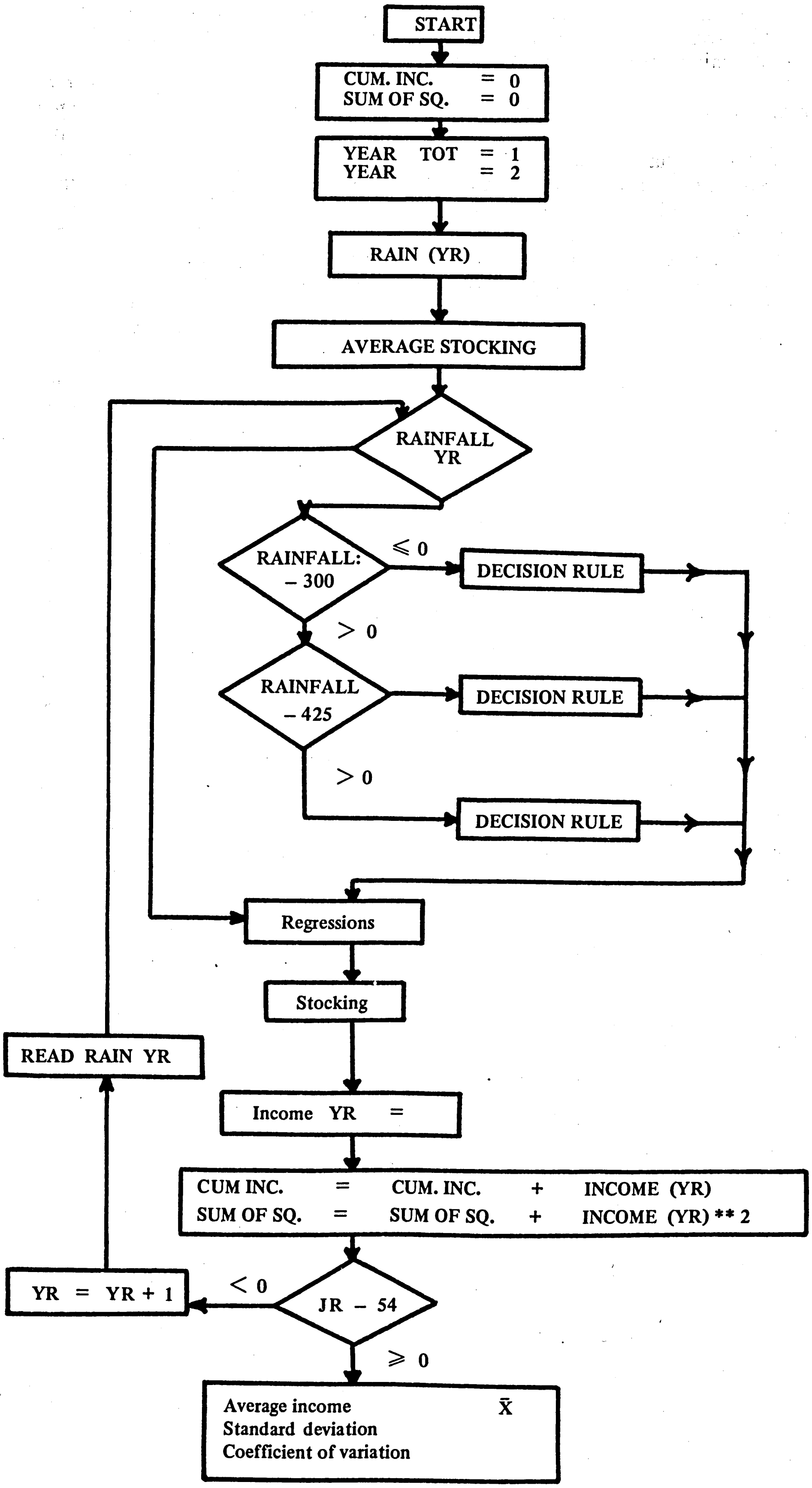

FIG. 1 – Flow diagram for simulation model

sold. If a rainfall of between 300 and 425 millimetres follows the same category, only 26-28 month and 39-42 month oxen are sold. If a rainfall of over 425 millimetres precedes a rainfall of between 300 and 425 millimetres, only 39-42 month old oxen are sold.

If a rainfall of over 425 millimetres occurs and follows a poor rainfall of less than 300 millimetres, only the available culled cows and heifers are sold. However, if this follows a rainfall of between 300 and 425 millimetres, 24 month old oxen can be sold. Where the rainfall is over 425 millimetres for two consecutive years only 39-42 month old oxen will be sold, that is to say if it has followed reasonably high rainfall years.

Further refinements and considerable amendments to the above production systems are possible for different categories of rainfall. The number of possible decision rules is vast and the above are only examples.

5. EMPIRICAL RESULTS

A programme was written in FORTRAN IV and solved on the IBM 370 computer of the University of Pretoria. Results appear in Table 1.

As regards herd ratios, only the composition of the breeding herd is given because the rest of the animals occur in differing numbers annually so as to fit the changing rainfall and therefore changing grazing conditions. Only real sales are taken to calculate the income at the relevant prices for a specific rainfall category. Capital income or loss from mass increases or losses, calf crops and mortalities were not taken into account.

6. DISCUSSION

The average rainfall on the farm selected over a period of 48 years was 428,5 millimetres, with a standard deviation of 125,4 and a coefficient of variation of 29,3 per cent.

According to Table 1 the 26-28 month ox production system 3 produces the highest average income and second highest average rate of turnover* of R10 859,57 and 40,58 per cent, respectively. At the same time this production system had the highest coefficient of variation in income by contrast with the more inflexible weaner and steer production systems. The degree to which an entrepreneur is prepared to accept the risk of a high or low income will also dictate the particular production system that he should follow.

Apart from their acceptance of risk or otherwise, both ox production systems, that is to say marketing of oxen at 26-28 and 39-42 months, appear to produce better average results because the average minimum income is higher than the general average income in the weaner production system.

The more intensive weaner production system produces, in spite of higher management requirements, a lower average income (R6 771,29), but with a lower coefficient of variation (15,4 per cent). It therefore produces a more stable income. The average calving percentage was about 72 per cent throughout. A calving percentage of 90 per cent, as is required in such an intensive system, would probably have increased the average income to about R9 000 without a large accompanying increase in the coefficient of variation. However, it would put high demands on management, given the big fluctuations in annual rainfall, to maintain high calving percentages and weaning masses in such an intensive, inflexible weaner production system. It would involve sales of breeding animals or considerable additional feeding in dry years. Otherwise times of drought could only be overcome by maintaining throughout a relatively lighter veld stocking of about 33 kilograms per hectare (i.e. 9 hectares per large stock unit or 16 hectares per breeding animal). A further important factor that cannot easily be solved by management in such a system is that at times, particularly in January and February, it becomes exceptionally hot in the North-Western Transvaal. Cattle then eat less as a result of the high temperature and as a result of wilting of grazing, which is then less palatable. Short-term heat waves and droughts often occur. This could have an important influence on the libido of bulls, the heat cycle of cows and early embryo mortality.

The steer production system has the lowest average income, the lowest coefficient of variation and also the lowest rate of turnover. This semi-intensive system is, consequently, as regards income, the least attractive of the four, particularly in the light of the exceptionally high probability that it will produce an income of less than R7 000 (see Table 2).

The low average income could be partly ascribed to poor growth from weaning to about one year of age.

There appears to be a clear connection between average income, coefficient of variation and rate of turnover : the lower the average income, the lower the coefficient of variation and the rate of turnover and vice versa.

There are inherent differences between different systems in the relationship between rainfall in the previous and incomes in the present year (year t-1 and year t). If the rainfall in year (t-1) was less than 300 millimetres, an ox production system will realise a higher income in the year (t-1) because of higher sales during the drought. In year (t) there will be no oxen available for sale, but only culled cows and heifers. The result is a low income. The inflexible weaner system, on the other hand, has sales that do not vary between types of stock and in this system the size of the calf crop, weaning weight and selling

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* The rate of turnover was calculated as follows:

$$\frac{\text{Total sale in kilograms}}{\text{Stocking after sales} + 0{,}5\ (\text{total sales in kilograms})} \times \frac{100}{1} \text{ per cent}$$

It was therefore measured in kilograms and not in terms of total absolute stock number sales. If the rate of turnover is measured in terms of numbers sold, the weaner systems will give the highest rate of turnover.

TABLE 1 - Results of simulation for production systems : Herd composition after sales, income variation and comparison of standards of stockings

	Production system			
	Weaner	Steer	26-28 month ox	39-42 month ox
	1	2	3	4
Bulls	5,0	4,0	4,0	3,0
Cows	96,0	88,0	64,0	40,0
Large heifers	24,0	22,0	16,0	10,0
Heifers - 18 months	24,0	22,0	16,0	10,0
Average income (R)	6 771,29	6 223,37	10 859,57	10 233,54
Standard deviation (R)	1 041,59	799,33	3 138,45	2 510,40
Coefficient of variation (%)	15,4	12,8	28,9	24,5
Rate of turnover (%)	25,93	22,06	40,58	45,92
Total sales (kg)	16 215,1	14 903,0	26 005,2	24 505,3
A. Stocking (after sale) (kg/ha)	27,22	30,05	25,54	20,55
Plus 0,5 (sales) (kg/ha)	4,05	3,73	6,50	6,13
Average cattle stocking (kg/ha)	31,27	33,78	32,04	26,68
Total stockings (including game) (kg/ha)	43,25	46,72	44,32	36,90
B. Number of LSU (after sales)	137,8	148,8	141,1	117,5
Plus 0,5 (sales) LSU	17,9	16,4	28,7	27,0
Average number of cattle LSU	155,7	165,2	169,8	144,5
Total LSU with game and other stock	215,4	228,5	234,9	199,9
Total stocking in ha/LSU	9,29	8,75	8,51	10,00
C. Number of LSU (after sales)	162,8	162,6	143,9	113,4
Plus 0,5 (sales) LSU	17,9	16,4	28,7	27,0
Average number of cattle LSU	180,7	179,0	172,6	140,4
Total LSU with game and other stock	225,2	224,9	199,2	156,8
Total stocking in ha/LSU	8,88	8,89	10,04	12,76
D. Number of years with income < R3 000	-	-	2	1
R3 000 to R 4 999	2	4	5	1
R5 000 to R 6 999	28	44	-	1
R7 000 to R 8 999	22	4	-	17
R9 000 to R10 999	1	1	11	10
R11 000 to R12 999	-	-	24	18
>R13 00	-	-	11	5

A. Stocking in terms of kilograms per hectare. Only half of sales was taken because of sales during year.

B. Stockings in LSU converted from kilogram stockings.
1. Number of LSU (after sales) = total stocking of cattle after sales/454.
2. Total LSU sales = total sales in kilograms/454.
3. Average number of cattle LSU = 0,5 (LSU sales) + LSU after sales.
4. Total LSU with game and other stock = 3./72,3%.
5. Total stocking in ha/LSU = 4./2 000.

C. Stockings in LSU converted from general departmental standards.
1. Average number of LSU after sales.
2. Total LSU sales = total sales in kilograms/454.
3. Average number of cattle LSU = 0,5 (LSU sales) + LSU after sales.
4. Total LSU with game and other stock = 3./72,3%.
5. Total stocking in ha/LSU = 4./2 000.

B differs from C in the respect that the number of stock after sales is calculated according to general Departmental standards in the case of C, that is to say where : 1 LSU =
1 bull, cow or heifer over 2 years,
2 heifers 1-2 years, steers 1-2 years,
3 calves under 1 year,
1 ox over 2 years.

D. The number of years from the results in which a specific income falls is divided into categories. Income never exceeded R14 000 with any production system.

price are the main variables.

In the ox production systems the consequences of a dry year are therefore only really felt the following year, whereas they are felt immediately in the weaner system. A delay in the consequences of a poor rainfall year therefore occurs in an extensive system. Because the number of breeding cows remains relatively constant, however, the breeding programme is not seriously disrupted.

Table 2 shows an interesting characteristic of

TABLE 2 - Income probabilities of four production systems

Income level (R)	Probability that income will be lower			
	System 1 Weaner	System 2 Steer	System 3 Ox 26-28 months	System 4 Ox 39-42 months
3 000	0,000	0,000	0,038	0,019
5 000	0,038	0,075	0,132	0,038
7 000	0,566	0,906	0,132	0,057
9 000	0,981	0,981	0,132	0,377
11 000	1,000	1,000	0,340	0,566
13 000	1,000	1,000	0,792	0,906
15 000	1,000	1,000	1,000	1,000

results obtained, based on the analyses at chosen price levels, and provided eventualities remain within limits set in the analysis.

System 4 (ox sales 39-42 months) is regarded as the most flexible system, followed by system 3 (oxen 26-28 months), whereas system 1 (weaners) is the least flexible. In economic literature it is normally assumed that flexibility is used at the cost of average income losses to obviate the risk of losses or low incomes, for example, in an exceptional year. Table 2 shows, however, that the two flexible systems are the only ones with an appreciable probability that the income in any year will be less than R3 000. In addition, system 3 (oxen 26-28 months) shows by far the highest probability of an income level below R5 000. At this level the probability for older oxen and weaners is the same.

If it is taken into account that the older ox system should produce a considerably higher average income level than the weaner system and that the probability of an income level lower than about R3 000 for a system is very low (9 = 0,019), then it appears that if the assumptions on which the analysis is built are valid, the choice for the entrepreneur would in reality lie between the two ox systems. The choice will be a function of the relative usefulness that he would obtain from higher income and security. This relative benefit will be influenced by his personal capacities and the status of his business.[8]

So far the analyses have centred on income on a farm unit. Income per hectare can easily be derived from this and will show the same trends. In concluding we will discuss briefly, with the help of Table 3, how expected average incomes per breeding cow and per hectare will differ between the systems.

Because in the ox production systems cows and heifers naturally make up a smaller percentage of the herd it was to be expected that these two systems would produce higher incomes, variable costs and gross margin per cow or per cow and heifer. Nevertheless, these figures are important because breeding cows and heifers represent a fixed asset in the short term and it may therefore be proposed that an ox production system implies a replacement of fixed by variable assets and produces higher yields on fixed assets. Although an ox production system implies a lower turnover in terms of animals per unit of area, it also implies a faster turnover in respect of fixed assets. For an entrepreneur with serious capital limitations this aspect clearly has far-reaching implications.

7. FINAL EVALUATION

In this analysis it was indicated that, given the assumptions used, a more flexible ox production system in the North-Western Transvaal Sweet Bushveld would be associated in the long term with higher expected average incomes, but also a higher variation in incomes, than a weaner system. There are also differences in income variations between ox production systems. A steer production system compares poorly financially with weaner and ox production systems.

One aspect that is not included in the analyses is the possibilities of fodder cultivation, particularly perennial grazing such as buffel grass.

Where soils and climate allow, their planting can relieve the pressure on natural veld and eliminate over-grazing practices. The more efficient use of the veld that arises can in the long term result in a considerable increase in veld production. More livestock can be kept on the farm and the required size for a minimum viable unit can be reduced. A more stable and acceptable financial result can be obtained. It would, however, also require a considerable outlay. Such grazing may also be associated with the choice of other production systems.

It appears once again that undoubtedly the most important requirements for profitable production in areas with low and variable rainfall is that of adaptation to natural conditions.

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2. *Ibid.*

TABLE 3 - Average income per cow and large heifer for four production systems

Production system	Area per animal		Income per animal		Variable cost per animal*		Gross margin per animal		Gross margin per hectare
	Cow	Cow and large heifer	Cow	Cow and large heifer	Cow	Cow and large heifer	Cow	Cow and large heifer	
	ha		R						
Weaner (1)	20,8	16,7	69,09	56,43	52,08	41,67	17,01	14,76	0,89
Steer (2)	22,7	18,2	70,72	56,58	56,82	45,45	13,90	11,13	0,61
Ox 26-28 months (3)	31,2	25,0	169,68	135,74	78,12	62,50	91,56	73,24	2,93
Ox 39-42 months (4)	50,0	40,0	255,83	204,66	125,00	100,00	130,83	104,66	2,62

* A constant variable cost of R2,50 per hectare is assumed

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