

/ ANALYSIS OF FACTORS AFFECTING TRADITIONAL
AGRICULTURE IN EASTERN BOTSWANA

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by

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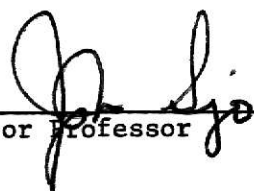
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TABLE OF CONTENTS

<u>Chapter</u>	<u>Page</u>
Acknowledgements	i
List of Tables	ii
List of Figures	vi
List of Maps	vii
I Introduction.	1
Background	1
The Problem	4
Objectives	5
Approach of the Study.	6
Plan of the Study.	6
II Traditional Agriculture in Botswana	7
Traditional and Commercial Agriculture	7
The Role of Agriculture in Botswana.	11
The Structure of Traditional Agriculture	13
III Review of Literature	20
Review and Analysis of Farm Management Plan.	20
Factors Affecting Agricultural Production.	45
Sources of Data.	61
IV Analysis of Some Factors Affecting Yield Per Hectare.	64
Multiple Regression Models and Results	70
Discussion of the Results.	81
Missing Observations and Data Problems	82

TABLE OF CONTENTS
(continued)

<u>Chapter</u>	<u>Page</u>
V Summary and Conclusions	84
Summary and Conclusions	84
Limitation of the Study.	85
VI Appendix	87
VII Bibliography.	
Abstract.	

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Livestock Inventory "1978-1981" Averages	10
2. Traditional Livestock, Crop and Livestock, and Crop Farms in Botswana by Region, 1980.	18
3. Traditional Farms Operated in Botswana by Production Mix, 1980	19
4. Farm Income, Income Per Man-Day, Hectare and Livestock Unit and Income as a Percent of Capital Invested, by Sample Stratum	22
5.1. Area Planted to Selected Crops by Sample Stratum . . .	28
5.2. Yields of Selected Crops by Sample Stratum	28
5.3. Average Labor Requirements Per Hectare, by Selected Crops and Sample Stratum	28
5.4. Labor Utilization of Average Farm by Type of Enterprise	30
5.5. Gross Margin Per Man-Day of Selected Crops by Sample Stratum	30
5.6. Gross Margin of Selected Crops by Sample Stratum . . .	30
6.1. Average Birth, Death, Offtake and Herd Growth Rates, by Type of Livestock and Sample Stratum, (a) 1980 and (b) 1981	35
7. Farm Income Per Farm and Livestock Unit by Type of Livestock and Sample Stratum for 1980 and 1981	43
8. Labor Utilization Per Hectare (M.D. per Hectare) by Crop and Categories: 1978, 1980, 1981.	60
9. Average Rainfall in Crop and Livestock Areas of Botswana	69
10. Sorghum Regression Results With Sorghum Yields Per Hectare as Dependent Variable	72
11. Sorghum Yield Per Hectare by Year for the Years 1978, 1980, and 1981	74
12. Sorghum Yield Per Hectare by Location for the Period 1978, 1980, and 1981	74

LIST OF TABLES
(continued)

<u>Table</u>	<u>Page</u>
13. Maize Regression Results With Yields Per Hectare As Dependent Variable.	75
14. Maize Yield Per Hectare by Year for Years 1978, 1980, and 1981	77
15. Maize Yields Per Hectare by Location for Years 1978, 1980, and 1981	77
16. Beans Regression Results With Bean Yields Per Hectare As the Dependent Variable.	78
17. Bean Yields Per Hectare by Year for Years 1978, 1980, and 1981.	80
18. Bean Yields Per Hectare by Location For Years 1978, 1980, and 1981	80

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Average Area Planted by Sample Stratum, 1978, 1980, and 1981	25
2. Average Yield Per Hectare by Sample Stratum for 1978, 1980, and 1981	26
3. Average Labor Use in Man-Days Per Hectare by Sample Stratum for 1978, 1980, and 1981 Cropping Seasons. . .	27
4. Average Gross Margin Per Man-day by Sample Stratum for Years 1978, 1980, and 1981	31
5. Average Gross Margin Per Hectare by Sample Stratum for Years 1978, 1980, and 1981	32
6. Average Livestock Units Per Farm By Sample Stratum for 1980 and 1981.	36
7. Average Percentage Birth Rates for Cattle by Sample Stratum in 1980 and 1981	37
8. Percentage Death Rate by Sample Stratum for 1980 and 1981	38
9. Percentage Offtake by Sample Stratum for 1980 and 1981	39
10. Percentage Herd Growth Rate by Sample Stratum for 1980 and 1981.	40
11. Gross Margin Per Livestock Unit by Sample Stratum for 1980 and 1981.	41
12. Total Gross Margin by Sample Stratum for 1980 and 1981	42
13. Rainfall and Total Grain Yield (maize and sorghum) for Years 1966-1980.	68

LIST OF MAPS

<u>Map</u>	<u>Page</u>
1. Republic Botswana (general map)	2
2. Rainfall (Annual Rainfall in Millimeters and Percentage of Seasonal Variability)	51
3. Location of Farm Management Data Collecting Stations.	62

**THIS BOOK
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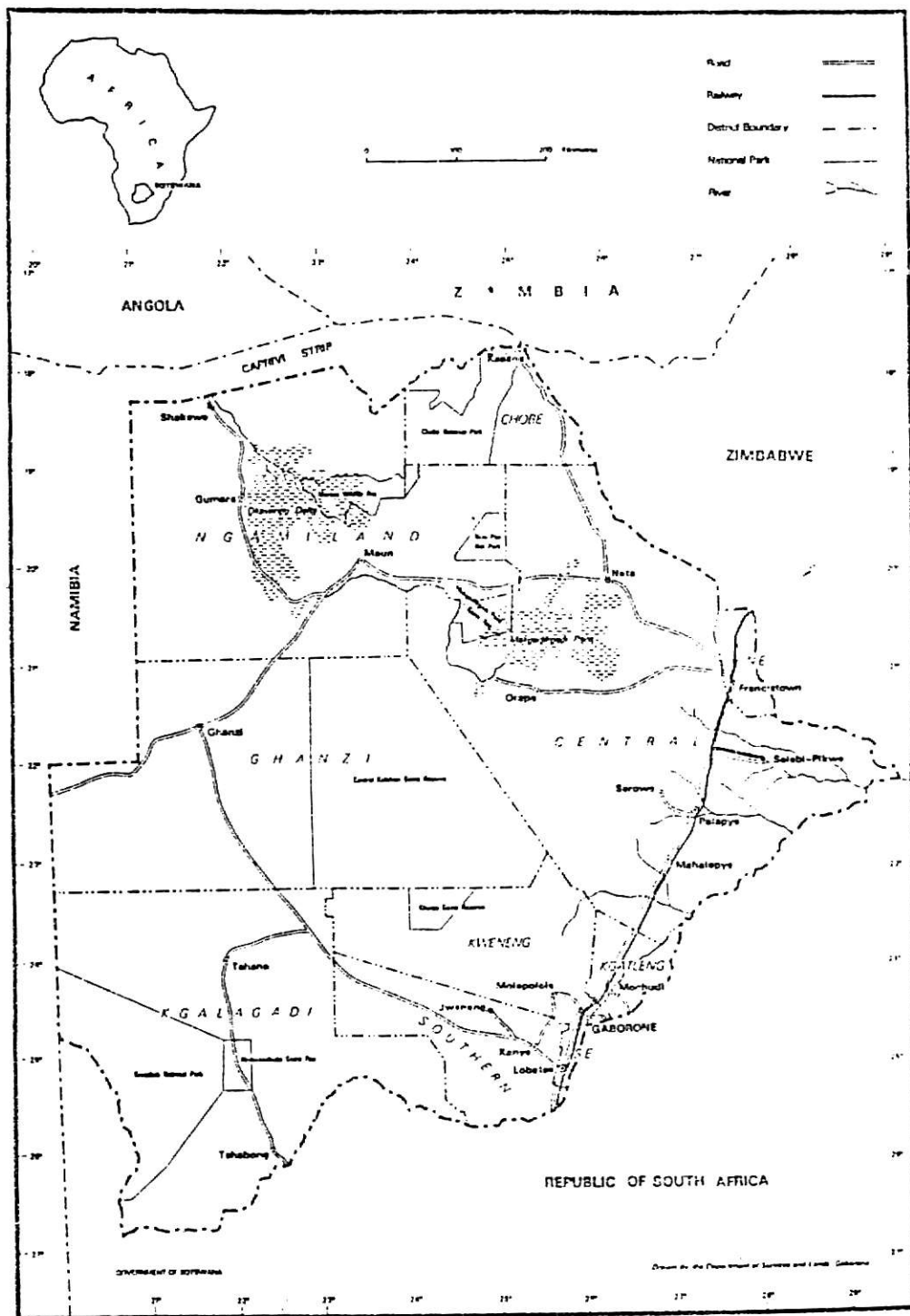
CHAPTER I INTRODUCTION

BACKGROUND

The Republic of Botswana occupies 225,000 square miles (582000 Km²) (about the size of Texas) and lies in the centre of the Southern African plateau at a mean altitude of 1,000 meters above sea level. Map 1 shows a general map of Botswana, its districts, towns and neighboring countries. It is characterized by scrub and tree savannahs on deep sands and by a general absence of surface water. The climate is continental and semi arid with erratic, unevenly distributed rainfall ranging from 250 millimeters in the southwest to 710 millimeters in the north. The eastern side of the country has more rainfall than the west and thus most of the crop production is in the eastern side of Botswana. Ninety percent of the rainfall is in summer between November and April.

Until 1978 agriculture had the highest contribution to the Gross Domestic Product (G.D.P.). The largest contribution of agriculture was from the livestock industry. Although its relative contribution to the G.D.P. has declined as a result of the expansion of the mining industry, agriculture is still by far the single most important economic activity for the rural population in terms of income generation, employment, food production and general welfare. The livestock sector (particularly cattle) continues to dominate agriculture with about 3 million cattle in 1981.

The preliminary results of the 1981 Population and Housing Census showed Botswana's population at 936,000 people with 83 percent of the



Map 1. Republic of Botswana.

population living in rural areas. High urban population growth due to a high urban migration. The population grows at a high rate of 5 percent per year. A large percentage of these rural dwellers are highly dependent on agriculture. Despite a greater attention given to agriculture since the attainment of political independence in 1966, agricultural output (particularly in arable agriculture) has not improved significantly for the majority of traditional farmers. There are wide yearly variations in yields per hectare, and there seems to be no consistency of certain factors affecting overall yields like rainfall, planting dates, etc. There also seems to be some amount of interaction between the factors affecting yields and yields per hectare, and the traditional farming system has not been fully understood.

Traditional agricultural production is greatly influenced by a whole range of factors, varying from the goals of traditional farmers, natural factors, husbandry practices, economic factors (resource endowments), technological constraints, etc. While there are studies conducted on some of these factors it is difficult to determine which of these factors greatly impact yields and yields per hectare. Obviously, for such continental climate, like in Botswana, rainfall plays a primary role in yield determination but it may be too simplistic to explain the wide variations of yields solely by rainfall fluctuations alone. Other factors do seem to play a major role in agricultural production of Botswana. It is from the understanding of prime factors and the interrelationships of factors affecting agricultural production and productivity in Botswana that attempts to reduce negative impacts and development of positive production factors may be sought.

THE PROBLEM

The traditional agricultural sector has its livestock and cropping operations intricably linked for their subsistence purposes. Livestock enterprises directly and indirectly affect cropping enterprises in terms of income provision, draft power provision, (planting date affected) for animal powered farms. The cropping activities complement the livestock enterprise by lessening the dependence of the family only on livestock farming and also providing food to the household. The production of both livestock and crops helps utilize the total family labor available. Female labor is particularly important for crop production and male labor for livestock production. However, in small stock (sheep and goats) and poultry, female labor and child labor is greatly utilized.

Despite the complementarity of livestock and crop enterprise for the farms, there seems to be problems that the traditional sector faces in this production system. Livestock death rates are very high in the traditional sector compared to the commercial sector. Even within the traditional sector there are wide differences that need to be explained. For example, 78% of traditional farms have low yields per hectare. There seems to be competition for production resources or inputs, primarily labor and capital by the crop and livestock enterprises. This competition is further increased by the fact that high labor demand of both livestock and crops occur at the same time. This is primarily during the rainy season. During this time the livestock operations such as herding, calving, milking, deticking, etc. need high levels of labor. On the cropping enterprises, ploughing/planting, weeding, and other crop production activities have to be attended to. The result is a critical shortage of labor to some farms. This labor shortage is indicated by

low yields per hectare, low labor use per hectare by some farms resulting in low gross margin per unit labor use. It has also been noted that farms successful in livestock enterprises are far less successful in their cropping activities.

Many factors impact on yields per hectare in Botswana such as rainfall, date of planting, rainfall distribution, labor use per hectare, husbandry practices (time of weeding, etc.), source and availability of draft power and edaphic factors, etc. The primary source of yield variation investigated has been rainfall but little has been studied on other factors that influence yields in the traditional farms. Whilst yearly fluctuations may be explained by rainfall and its distribution, there are differences in yields and yields per hectare within the same years that implies that there may be more factors besides rainfall and its distribution. Rainfall may also vary greatly within short distances. Other factors like labor use, planting date and other factors may be also essential. It is the purpose of this report to discuss the factors that seem to affect yields in general and yields per hectare based on the existing data.

OBJECTIVES

The objective in this study is to explain and discuss factors affecting crop production yields and yields per hectare and to review the role of the livestock sector in traditional farming in Eastern Botswana.

Specific objectives included are:

- (i) To analyze some factors affecting yields and yields per hectare in general for Eastern Botswana.

- (ii) To review literature and statistical data regarding the interaction and problems of both livestock and arable farming in the traditional sector.
- (iii) To study the effects of some factors determining yield per hectare on sorghum, maize, and beans using the farm management survey results.

APPROACH OF THE STUDY

A linear regression model will be used in the study, together with the model, other factors impacting on the traditional agriculture will be reviewed and the statistical evidence shown in the discussion.

It will not be possible to include most and even some of the most important variables in the model due to data problems. In this study, however, the primary focus will be to review literature on the source of variation in traditional agricultural production in an effort to understand the problems of traditional agriculture in general in Botswana.

PLAN OF THE STUDY

A general overview of the traditional agriculture will be laid out in contrast with the commercial agriculture, and an analysis of the importance of agriculture and its structure.

A discussion of factors not included in the model will be discussed to determine their role in traditional agriculture and their possible implications.

Finally, an economic analysis of some factors impacting on yields per hectare will be analyzed.

CHAPTER II TRADITIONAL AGRICULTURE IN BOTSWANA

TRADITIONAL AND COMMERCIAL AGRICULTURE

In Botswana, agriculture is in two distinct sectors, the commercial and traditional (subsistence) sectors. These two sectors differ substantially in crops produced, management, husbandry practices, sources of draft power, and size of farms.

The commercial sector consists of about 0.5 percent of the total number of farms, yet this sector has 15 percent of the total number of cattle, 3.6 percent of the total small stock (sheep and goats), and 15 percent of the total crop production, and about 70 percent of the total cash crop production.¹ The commercial sector is usually well endowed with production resources such as capital, management, tractors, and other farm equipment. The commercial sector is more specialized and less diversified and it produces most (70 %) of cash crops and it is very rare to find commercial farms with livestock and several crop enterprises. Some traditional farmers owning large numbers of cattle at cattle posts are, however, more market oriented or semi-commercial farms in their cattle enterprises.

The traditional sector, however, is more homogeneous in their resource endowments and agricultural activities, with 70 percent of the traditional sector raising both livestock and crops. About 12 percent keep cattle and/or small stock only, about 85 percent of farms cultivating crops and only 15 percent of the farms grow crops only. This simple comparison shows that at least 70 percent of farms raise both

¹1979-1981 Botswana Agricultural Statistics: Division of Planning & Statistics, Ministry of Agriculture.

livestock and crops. A great number of the traditional sector that raise crops only are dependent also on animal powered farms for their ploughing/planting and other agricultural activities such as hauling grain, water, etc. There are other sources of draft power like tractors which are usually scarce and relatively expensive.

The traditional sector grows four main crops, sorghum, maize, millet, and beans/pulses. Other crops include sunflower, sweet reed, watermelons, pumpkins, and ground nuts. Maize is popular in the south-east and millet and ground nuts in the northeast. In the livestock enterprises, cattle, sheep and goats, donkeys, and chickens are common farm animals. It is not uncommon to find most if not all these crops and livestock raised by the traditional farms.

Average cattle owned and crop areas planted by commercial farms are usually thirty times greater than the average traditional farms and small stock holdings about ten times greater than average traditional farms. Apart from showing the differences in sizes of farms, it also demonstrates the different amounts of input that must be matched between the two sectors. The commercial sector requires modern technology and management.

Whereas birth ratios of livestock are the same between traditional and commercial farms, there is great variation in deaths, home slaughter, and sales ratios. Death ratios on traditional farms are four-fold those of commercial farms in cattle and about twice those of commercial farms in sheep and goats.² While this difference reflects the management differences it may also be due to the selection practiced by the commercial farms, which may account for the reduced mortality

²Op. Cit. Planning and Statistics Division, Ministry of Agriculture.

in the commercial sector. Table 1 contrasts the traditional and commercial sector in birth, death rates in cattle, sheep and goats.

Clearly there are management problems associated with the traditional agricultural practices shown by high death rates.

The traditional sector also seems to be far less market oriented than the commercial sector. This implies that there may be other objectives together with market determined objectives. In fact, traditional farmers are often hypothesized to be motivated by multiple objectives rather than a single one, like profit maximization. This has been demonstrated in Botswana's traditional sector through having a wide variety of agricultural activities per farm. Most traditional farmers objectives include provision of household food requirements, risk minimization, diversification, and maximum profit.³ These multiple, conflicting decision-making objectives are usually achieved through the many agricultural activities, usually embarked upon by subsistence farmers. The traditional section in Botswana raise four main crops, sorghum, maize, beans, and millet. In addition to these crops there are other crops like sunflower, watermelons, sweet reed, ground nuts, and pumpkins grown. The livestock activities include cattle, sheep, goats, chickens, and donkeys and mules for draft purposes.

Despite the advantages of economies of scale from ownership of large cattle herds and farmlands in the commercial sector, their

³Barnett, D., Blake, B., and McCarl, B.A. "Goal Programming via Multi-dimensional Scaling Applied to Senegalese Subsistence Farms." American Journal of Agricultural Economics, Volume 64, Number 4 (1982). pp. 720-727.

Table 1. Livestock Inventory "1978-1981" Averages.

Type of Livestock	Sectors	Ratio of Birth to Females %	Ratio of Death to Total %	Ratio of Sale to Total %	Ratio of Home Slaughter to Total %
Cattle	Traditional	58.15	12.29	8.421	0.833
	Commercial	60.30	3.79	24.66	1.00
Goats	Traditional	50.46	39.63	4.69	5.64
	Commercial	45.2	20.1	6.27	10.67
Sheep	Traditional	41.05	33.89	5.90	6.49
	Commercial	43.37	16.67	5.24	24.40

Source: 1979-1981 Botswana Agricultural Statistics, Ministry of Agriculture: Planning and Statistics

production and productivity does not guarantee that the commercial farmer in Botswana are technically or economically more efficient than the traditional farmers.⁴ It may be just a technological difference between the two sectors and less to do with optimal allocation of the resources or inadequate production resources.

THE ROLE OF AGRICULTURE IN BOTSWANA

Agriculture constitutes about 15% of the Gross Domestic Product (G.D.P.) and it grows at a rate of about 7% per annum. This share declined from 41.8 in 1967/68 to 15 percent in 1981. While the mining sector rose from 2% in 1967/68 to about 32% in 1981 with a 15% rate of growth per annum¹. Botswana's export earnings primarily depend on minerals and beef. In addition to contributing to the government capital formation, agriculture has also accounted for the rural sector personal income and income distribution despite the highly unequal income distribution stemming from the skewness of cattle ownership. The agricultural sector is comprised of 76 percent cattle, 4 percent small stocks, 9 percent crops, and other crops and livestock the remaining 11 percent. This shows the strength of the cattle industry as a source of government revenue and also to the livestock producers. It is probably the single most important activity that supports the improvement of general welfare of farmers since cattle ownership is fairly wide even though it is skewed.

⁴Litschauer, J. G. and Kelly, W. F., Traditional versus Commercial Agriculture in Botswana, Planning and Statistics, Ministry of Agriculture, Botswana. pp. 6-7.

¹National Development Plan 1979-85. Ministry of Finance and Development Planning, November, 1980. Page 39.

The crop production activities are known to account for 9 percent but their role may be fairly important since arable agriculture is oriented to household consumption and less so towards the market. However, crops can be seen to act as a "buffer" against changes on the household yearly food needs and complementing the livestock sector's support to the household.

Because the rural economy is so dependent on agriculture for income generation, employment, and food production and because Botswana's agriculture is highly "drought-prone", the whole rural economy is "drought-prone". Self-employment, hired employment, incomes and other non-agricultural activities such as beer-brewing and hand crafts are adversely affected as a result of the dramatic fall in incomes and demand for goods and services during drought. The rural labor market during drought, particularly female labor, become both unemployed and/or underemployed. Hired labor in crop production activities are eliminated, such as destumping, ploughing, and other crop activities utilizing hired labor like fencing, birdscaring, hauling water and grain, harvesting, and other contractual arrangements and activities that exchange labor.

The livestock labor demand, however, does not decrease dramatically but there is tremendous pressure on the livestock sector to sell or keep the livestock, both to compensate for the food need resulting from the drought and to lessen the risk of the death of the livestock as a result of the drought. Other non-agricultural activities which are linked with the rural economy are also adversely affected. The incomes generated from the agricultural sector support education, taxes, and in some cases rural development activities.

THE STRUCTURE OF TRADITIONAL AGRICULTURE

About 70 percent of traditional farms practice both crop and livestock farming. Cattle farming is popular because of the use of cattle for draft power, milk, and their saleable potential. Other livestock include small stock (sheep and goats), donkeys, and poultry. Small stock and donkeys are livestock for the lower income households of the traditional sector. Since 70 percent of traditional farms producing crops use cattle draft power for ploughing, it is highly important for many households to have adequate cattle for ploughing. Tractor and donkey draft power are less widely used but their use has become increasingly important. Farms without draft power are dependent on farms with draft power for hiring and exchange of labor for ploughing.

Cattle ownership is skewed in Botswana, yet cattle ownership is highly correlated with wealth, i.e., the more cattle the more wealthy farms are. Therefore, most traditional farms with no cattle are poor. This results in these farms ploughing small hectarages, late ploughing/planting, and may also lack some capital resources for crop farming.

In general, the crop production enterprise is for meeting the food needs of the household, while livestock production enterprise is mainly for cash needs in the traditional sector. The livestock sector also supports food by milk production but this contribution is not as much as the income provision by the cattle enterprises.

The traditional agricultural sector is more household oriented and less market oriented, particularly in its cropping activities. There has been, however, an increasing market orientation by traditional farmers, particularly in the livestock activities. This has been shown by an ever increasing marketing of cattle to the Botswana Meat Commission

(BMC) rather than selling to speculators which tend to offer lower prices. But as long as 70 percent of traditional farms use animal draft power then other objectives for cattle raising will include provision of draft power and milk provision.

The agricultural produce has been less targeted to the market because long distances between the markets and the farms which tends to make transportation to markets uneconomical. However, it is not uncommon to find farm produce in the markets and usually these products are sweet reed, watermelons, and maize. With increasing transport facilities, it is likely that the objectives of farmers may be more market geared and this trend is already evident in farms near towns. Sweet reed and watermelons can provide considerable income and a source of food during the growing season, particularly because their production is not highly labor demanding. It has also been noted that sometimes watermelons do survive even when sorghum and maize were very unsuccessful. There are several uses of watermelons, such as "watermelon wine," for sale, domestic consumption of watermelons, or gifts. These crops are fairly popular but the main emphasis of farmers seems to be longer term sources of food supply in crops like sorghum, maize, millet, and beans, rather than seasonal food sources like watermelons and sweet reed.

It is also a typical traditional farm structure to mix livestock and cropping activities together with a purpose to make use of female, male, and child labor. Female and child labor is utilized in crops and smallstock (sheep and goats), donkeys, and activities in crops varying from birdscaring, weeding, and other supporting activities like water collection. The cattle activity usually utilizes the bulk of the male

labor, as female and child labor is less productive.

The traditional sector has been historically influenced by the formal employment, specifically by migrant labor to South African mines. This has also been part of the goal to provide secure food income for the household. This practice was most favorable after the ploughing/planting had been completed and during less favorable years in crops. Because of mixing livestock and crops together in the same areas, other adverse implications are the amount of labor that has to be used in herding livestock away from the crops and in many areas there is quite significant damage of crops by the livestock. But basically, this is to point out that there are both positive and negative interactions that result in this practice, like competition for labor during cropping season which is also the calving season when labor demand is high, both in livestock and cropping activities. Because crop production is seasonal, it does make sense having livestock activities to utilize the labor during the other months when no crops are grown. Again livestock production is less risky than crop production because the climate of Botswana renders livestock production at a higher comparative advantage to crop production. It seems that the traditional agriculture structures itself with the objective of diversification or minimization of risk by producing both livestock and crops to utilize the labor fully, to get income from livestock activities and to complement crop production by provision of draft power.

Tables 2 and 3 show different production mixes by farmers for 1980. Although these figures are just for one year, the percentages do seem to represent what can be expected from the country in general. In favorable

rainy years some traditional households raising cattle only may raise crops but in years where rainfall does not seem favorable, many households with higher livestock may choose not to grow crops. The figures are fairly representative since 1980 itself is fairly representative of a fair year in terms of rainfall. These tables show the tendency for the traditional sector to mix many enterprises per farm in general. Those with few production mixes may be usually influenced by labor or resource shortages.

Because of the uneven cattle ownership, even though it may seem that the traditional sector own large cattle populations, many households own very small herd sizes and this increases the draft power problems and since few households own large herds, there is greater dependence on households owning a large number of cattle.

There also seems to be a considerable interaction of various economic factors and the production resources. There is a lot of formal and informal markets for farmers to have access to inputs such as labor, seeds, draft power, and selling of surplus production. Examples of informal markets involve sharing, borrowing and managing, draft power, and also exchanging labor during cropping seasons, particularly during ploughing/planting and weeding. These may involve families and relatives or just in the form of informal contracts between households. These are informal since in some cases there are no market prices since payments are in kind, or just reciprocated in a different manner. These factors need to be realized but it may be difficult to quantify and separate their effects. Some households may be pooling to solve their resource constraints, such as draft and labor resources. This is why it seems

the aim of the overall farm or farmers design their "production mix" to "match" in terms of its enterprises and resources for households such as household needs, labor, draft power, and income requirements.

Table 2. Traditional Livestock, Crop and Livestock, and Crop Farms in Botswana by Region, 1980.

Region	Cattle Numbers	Production Mix				Percent of Total (farms)
		Livestock Farms ¹	Crop & Livestock Farms ²	Crop Farms	Total Farms	
Southern	318000	3,700 (27.0%)	8,650 (63.1%)	1,350 (9.9%)	13,700 (100.0%)	17.1
Gaborone	395000	2,500 (14.0%)	12,100 (67.6%)	3,300 (18.4%)	17,900 (100.0%)	22.4
Central	956000	3,800 (15.1%)	18,300 (72.9%)	3,000 (12.0%)	25,100 (100.0%)	31.4
Francistown	348000	1,400 (13.1%)	8,450 (79.0%)	850 (7.9%)	10,700 (100.0%)	13.4
Maun	354000	1,400 (13.5%)	6,350 (61.1%)	2,650 (25.5%)	10,400 (100.0%)	13.0
Western	84000	1,600 (72.7%)	500 (22.7%)	100 (4.5%)	2,200 (100.0%)	2.7
TOTAL	2455000	14,400 (18.0%)	54,350 (67.9)	11,250 (14.1%)	80,000 (100.0%)	100.0

¹ Includes: (a) cattle only; (b) cattle and smallstock; (c) smallstock only; (d) other livestock only.

² Includes: (a) cattle and crops; (b) cattle, smallstock and crops; (c) crops and smallstock.

SOURCE: The Structure of Traditional Agriculture in Botswana, February 1981, p. 7.

Table 3. Traditional Farms Operated in Botswana by Production Mix, 1980

Production Mix ¹	Traditional Farms	Percent of Total
I. Farms with Cattle:		
1. Cattle only	3,900	4.9
2. Cattle & Smallstock ²	5,450	6.8
3. Cattle & Crops	15,800	19.8
4. Cattle, Smallstock & Crops	32,550	40.7
SUBTOTAL	57,700	72.1
II. Farms without Cattle:		
1. Crops only	11,250	14.1
2. Crops & Smallstock	6,000	7.5
3. Smallstock only	2,700	3.4
4. Other Livestock only ³	2,350	2.9
SUBTOTAL	22,300	27.9
TOTAL	80,000	100.0

¹All categories of farms may raise other livestock (donkeys, mules, pigs, chickens, and horses).

²Smallstock includes sheep and/or goats.

³Farms which raise only donkeys, mules, pigs, chickens, and horses.

SOURCE: The Structure of the Traditional Agriculture in Botswana, 1981, p. 6.

CHAPTER III

REVIEW OF LITERATURE

REVIEW AND ANALYSIS OF FARM MANAGEMENT DATA

In general the traditional sector derives 15-25 percent of its total farm income from the crop production enterprises. In some drought years it is very common to obtain nothing from the crop production enterprises. A distinction has to be made, however, between farms with adequate draft power and those with inadequate draft power, and also between male and female headed households. Female headed households with inadequate draft power are the most highly dependent on crop production for their farm income. About 50-78 percent of their farm income is from crop production. This category is followed by the male headed households with inadequate draft power which derives 30-50 percent of its total farm income from crops. Those farms with adequate draft power derive a small percentage of farm income from the crops, 10-30 percent, while the female headed households are more dependent on crops.¹ Income from crops is very undependable. This is because the crop production itself is very prone to weather conditions in Botswana and has been greatly unpredictable and production has been greatly inconsistent. Incomes from livestock production have been relatively stable and with an increasing trend. The livestock income does not have much year-to-year fluctuations as a result of changes in rainfall and other climatic conditions.

Per man-day incomes are higher in households with adequate draft power than those without draft power. It is interesting to note that the income per man-day is higher in livestock than in crops for farms with adequate draft power but vice versa for those farms with inadequate

¹Farm Management Survey 1978-1981. Ministry of Agriculture, Division of Planning and Statistics.

draft power. This also shows emphasis by this sector to crops due to higher dependence on the crops, besides the fact that the livestock are too few to generate larger incomes per man-day. Tractor powered farms seem to be unprofitable and very rarely profitable, nineteen eighty was an exception. This is due to higher variable costs incurred in fuel and other maintenance costs. However, tractor powered farms are not really in such a bad position since there is usually a high demand for hired tractor power during ploughing. There is no data showing the exact benefits, but a greater amount of income is from hiring-out tractor draft power to other farms without draft power or those who supplement their owned animal traction to plough larger hectarages.

Tables 4.1 and 4.2 are the production mix of the different categories and the classification of farms used in the farm management survey. It is also common in these farms that many farms practice mixed farming, particularly production of crops and livestock. These two tables summarize the characteristics of the different categories in the years 1978, 1980, and 1981.

A classification greatly used in the farm management is the categorizing between top third, middle third, or bottom third of crop and top third, middle third, or bottom third of livestock farms. This classification is based on the income gained on each of the two (crop and livestock) activities. Farms with the highest incomes in crop activities are classified as top third crop farms. Farms with highest incomes and best performance from livestock enterprises are classified as top third livestock farms. Those in the bottom third either in crops or livestock activities are the lowest. It is possible for a farm to be among the top third crop farms and the same farm to be among the

Table 4. Farm Income, Income Per Man-Day, Hectare and Livestock Unit and Income as a Percent of Capital Invested, by Sample Stratum.

1978										1980										1981									
All Farms					Income as Percent of Capital Invested ¹					All Farms					Income as Percent of Capital Invested ¹					All Farms					Income as Percent of Capital Invested ¹				
Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.	Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.	Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.	Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.	Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.	Total Income	Income Per M.D.	Income Per Ha.	Income Per L.U.	Income Per L.U.
45.28	0.41	6.98	-	-	17.3	157.08	1.58	27.70	-	88.7	157.08	1.58	27.70	-	88.7	139.22	1.95	30.39	-	61.87	139.22	1.95	30.39	-	61.87	139.22	1.95	30.39	-
331.48	1.90	-	14.05	-	13.1	453.91	3.2	-	17.94	12.5	453.91	3.2	-	17.94	12.5	772.87	5.81	-	22.47	13.86	772.87	5.81	-	22.47	13.86	772.87	5.81	-	22.47
376.76	1.32	-	-	-	13.5	610.99	2.55	-	-	16.1	610.99	2.55	-	-	16.1	912.09	4.48	-	-	15.73	912.09	4.48	-	-	15.73	912.09	4.48	-	-
Adequate Draft					Adequate Draft					Adequate Draft					Adequate Draft					Adequate Draft					Adequate Draft				
Male					Male					Male					Male					Male					Male				
38.21	0.24	7.36	-	-	10.4	206.29	1.66	28.33	-	76.9	206.29	1.66	28.33	-	76.9	136.97	1.79	28.74	-	46.22	136.97	1.79	28.74	-	46.22	136.97	1.79	28.74	-
438.28	2.29	-	14.31	-	14.2	571.17	3.66	-	17.63	12.4	571.17	3.66	-	17.63	12.4	403.83	3.07	-	13.92	8.72	403.83	3.07	-	13.92	8.72	403.83	3.07	-	13.92
477.49	1.55	-	-	-	13.8	777.46	2.77	-	-	16.0	777.46	2.77	-	-	16.0	582.30	2.76	-	-	12.14	582.30	2.76	-	-	12.14	582.30	2.76	-	-
Inadequate Draft					Inadequate Draft					Inadequate Draft					Inadequate Draft					Inadequate Draft					Inadequate Draft				
Female					Female					Female					Female					Female					Female				
47.30	0.75	10.58	-	-	124.2	110.85	1.87	37.20	-	212.3	110.85	1.87	37.20	-	212.3	53.29	1.72	30.28	-	249.72	53.29	1.72	30.28	-	249.72	53.29	1.72	30.28	-
29.90	0.31	-	5.23	-	5.2	30.20	0.50	-	12.05	8.9	30.20	0.50	-	12.05	8.9	38.22	0.90	-	26.46	17.70	38.22	0.90	-	26.46	17.70	38.22	0.90	-	26.46
77.20	0.49	-	-	-	16.4	141.05	1.18	-	-	45.0	141.05	1.18	-	-	45.0	111.51	1.16	-	-	31.84	111.51	1.16	-	-	31.84	111.51	1.16	-	-
Male					Male					Male					Male					Male					Male				
46.31	0.51	10.31	-	-	49.5	90.89	1.38	28.40	-	214.9	90.89	1.38	28.40	-	214.9	126.78	2.52	43.12	-	111.02	126.78	2.52	43.12	-	111.02	126.78	2.52	43.12	-
47.79	0.41	-	6.71	-	7.1	87.29	1.04	-	16.05	12.4	87.29	1.04	-	16.05	12.4	221.00	1.95	-	26.82	17.73	221.00	1.95	-	26.82	17.73	221.00	1.95	-	26.82
94.10	0.45	-	-	-	13.4	178.18	1.19	-	-	25.2	178.18	1.19	-	-	25.2	347.78	2.14	-	-	25.57	347.78	2.14	-	-	25.57	347.78	2.14	-	-

¹This is not returns to capital in the traditional sense since there was no charge for land, family labor and management.

NOTE: Figures in parenthesis are average area planted in hectares or livestock units as appropriate.

²Pula is the Botswana currency. 1.00 Pula - \$0.94.

bottom third livestock farms. In fact, farms which are "best" livestock farms (top third) have been noted to be far less so on their crop enterprises.² Farms may be among the top, middle, or bottom in both crop and livestock enterprises or any combinations of these categories. This makes it difficult to assess their resource availability when the analysis is split for the two main farm enterprises. This method of analysis does not indicate whether these are tractor, donkey, cattle farms, adequate or inadequate draft farms. It is essential to know the whole farm performance to identify its production bottlenecks. Because this analysis mixes tractor, cattle, and donkey farms it is rather difficult to compare them in great detail. This classification, however, will be used since it gives other insights into the economics of mixed farming.

Figures 1, 2, 3, 4, and 5 are very closely related as these are based on the same data. From Figure 1, it is noted that the top third crop farms planted consistently low hectarages compared to the middle third and bottom third farms. In 1979 and 1980, the middle crop farms planted the largest hectarages but in 1981 the bottom third farms had the highest total area planted.

Figure 2 shows the yield per hectare by sample stratum. Despite the large hectarages planted by middle and bottom third farms, the yield per hectare is low and falls very sharply from the top third down to the bottom third crop farms.

The labor use per hectare follow the yield per hectare pattern in all three years in Figure 3. The top third farms intensify by more man-days per hectare despite their relatively small area planted. It is, therefore,

²Farm Management Survey 1980. Ministry of Agriculture, Division of Planning and Statistics, page 12.

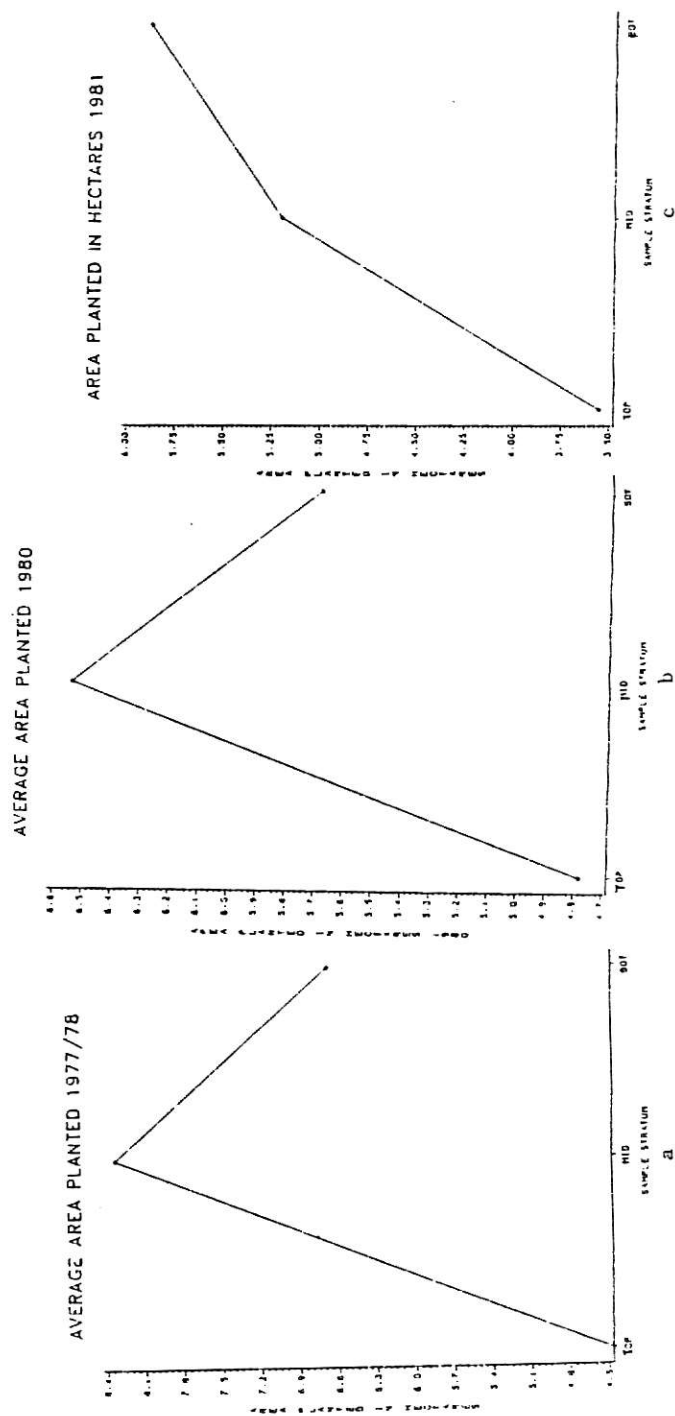


Figure 1. Average Area Planted by Sample Stratum, 1978, 1980, and 1981.

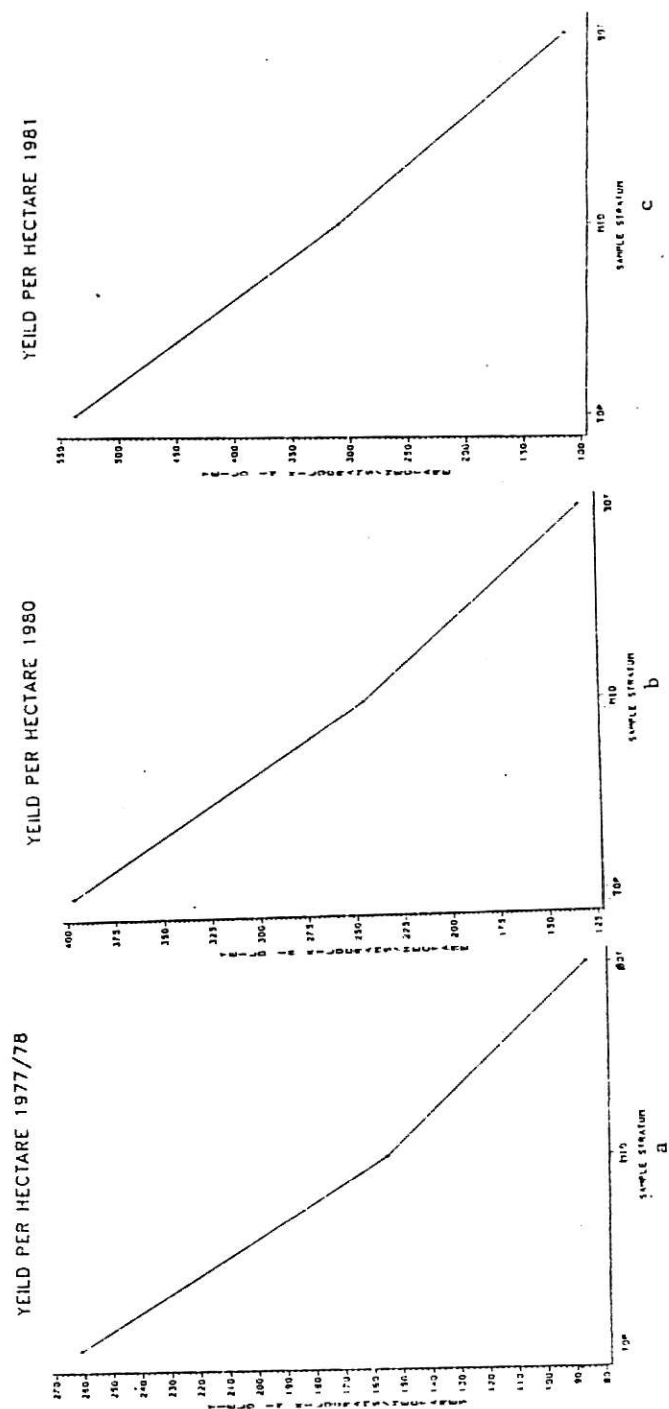


Figure 2. Average Yield Per Hectare by Sample Stratum for 1978, 1980, and 1981.

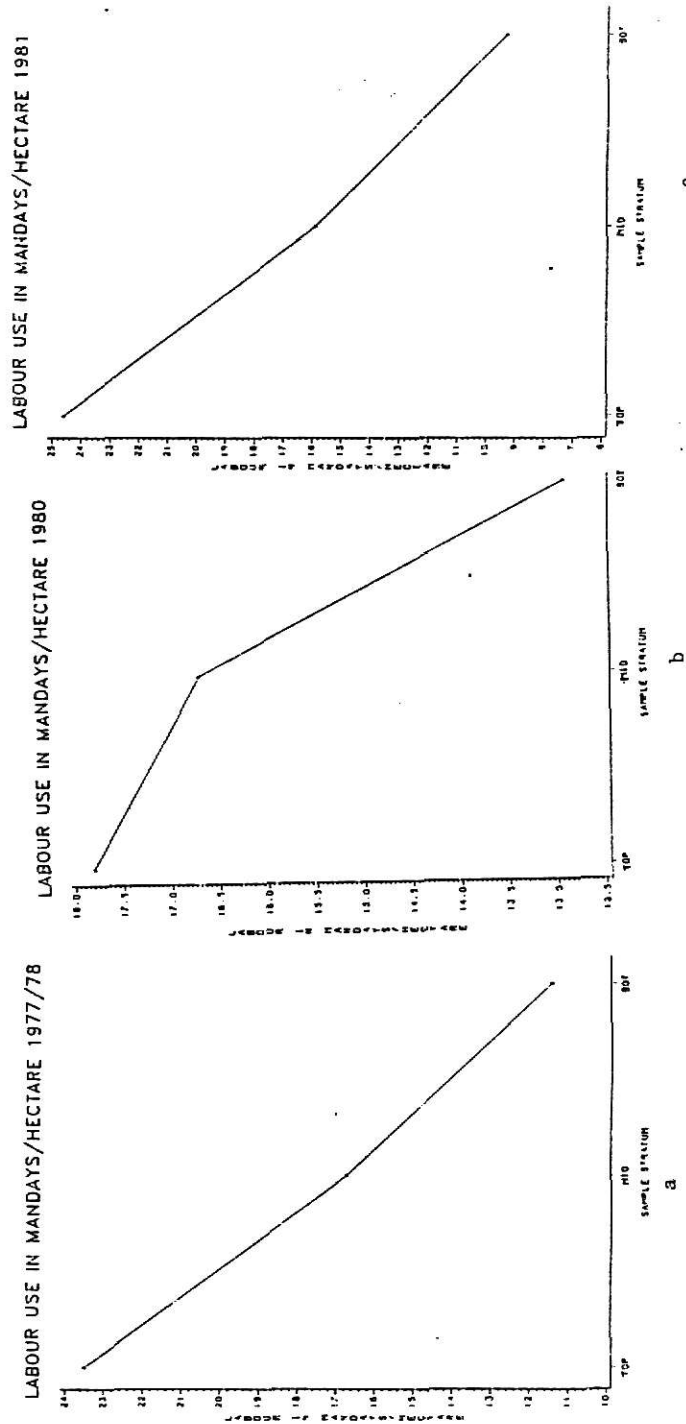


Figure 3. Average Labor Use in Man-Days Per Hectare By Sample Stratum for 1978, 1980, and 1981 Cropping Seasons.

Table 5.1. Area Planted to Selected Crops by Sample Stratum.

	1977/78				1980				1981			
	Top		Middle		Top		Middle		Top		Middle	
	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop
	Hectares				Hectares				Hectares			
Sorghum	2.76	1.77	3.61	2.94	2.55	1.76	3.11	2.76	2.30	1.44	2.54	3.37
Maize	1.73	1.08	2.30	1.83	1.65	1.28	1.84	1.85	1.01	1.06	1.23	0.91
Beans	0.87	0.64	1.26	0.54	0.78	0.78	0.91	0.66	0.64	0.59	0.78	0.69
Sunflower	0.66	0.37	0.74	0.91	0.19	0.08	0.24	0.25	-	-	-	-
Millet	0.39	0.52	0.26	0.39	0.34	0.60	0.30	0.12	0.27	0.19	0.36	0.30
Watermelon	-	-	-	-	-	-	-	-	0.06	0.04	0.04	0.13
Sweet Reed	-	-	-	-	-	-	-	-	0.06	0.04	0.04	0.13
Ground Nuts	-	-	-	-	-	-	-	-	0.04	0.04	0.07	0.01
Other	0.08	0.09	0.06	0.06	0.16	0.28	0.14	0.05	0.08	0.05	0.03	0.16
Total	6.49	4.47	8.33	6.67	5.67	4.78	6.34	5.69	4.58	3.55	5.20	5.88

Table 5.2. Yields of Selected Crops by Sample Stratum.

	1977/78				1980				1981			
	Top		Middle		Top		Middle		Top		Middle	
	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop
	Kgs./Ha.				Kgs./Ha.				Kgs./Ha.			
Sorghum	156	260	166	63	305	504	295	188	239	525	243	111
Maize	159	262	144	108	174	289	194	74	361	550	379	121
Beans	123	230	92	63	98	95	109	86	183	206	185	158
Sunflower	147	295	134	85	55	-	47	78	-	-	-	-
Millet	130	205	85	42	319	452	151	61	301	562	276	159
Watermelon	-	-	-	-	-	-	-	-	712	1232	1005	332
Sweet Reed	-	-	-	-	-	-	-	-	560	1575	1179	71
Ground Nuts	-	-	-	-	-	-	-	-	134	272	81	49

Table 5.3. Average Labor Requirements Per Hectare, By Selected Crops and Sample Stratum.

	1977/78				1980				1981			
	Top		Middle		Top		Middle		Top		Middle	
	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop	All Farms	1/3 Crop
	H.D./Ha.				H.D./Ha.				H.D./Ha.			
Sorghum	19.2	29.8	19.0	11.5	23.5	25.4	26.2	19.4	13.8	23.6	15.4	8.4
Maize	10.3	12.5	10.2	9.4	10.4	16.6	10.5	6.0	14.9	24.5	11.6	8.1
Beans	18.8	26.0	16.6	10.5	14.2	16.1	13.6	12.8	18.8	20.7	20.0	15.1
Sunflower	9.8	10.2	11.9	7.4	5.3	2.6	7.9	5.9	-	-	-	-
Millet	23.0	20.6	27.7	19.0	21.7	25.0	16.8	17.5	24.2	35.0	25.5	15.1
Watermelon	-	-	-	-	-	-	-	-	13.1	25.8	12.7	7.1
Sweet Reed	-	-	-	-	-	-	-	-	13.6	51.5	11.1	1.8
Ground Nuts	-	-	-	-	-	-	-	-	37.6	52.5	30.5	33.4
Average	17.0	23.5	16.7	11.4	15.8	17.8	16.7	12.9	15.6	24.6	15.9	9.3

implicit that the large area planted by the middle and bottom crop farms results in less labor use per hectare since the areas are larger. It may be very important for a farm to assess its labor availability rather than maximizing areas planted. There was no data on the total labor available for all the three sample strata. Assuming labor availability is the same for all farms in the sample strata, then the general conclusion of low labor use per hectare because of large areas planted may be easily conceivable.

Since most farms have both crops and livestock, labor has to be split between these. Table 5.4 shows that generally livestock demand more labor than crops partly because livestock are managed all year, whereas crops are produced during the cropping season (November - June). This shows that labor is a scarce resource in Botswana. The same table shows that hiring labor is in both crop and livestock enterprises, with livestock hiring more labor than crops. About 10-15 percent of farm labor is hired. However, no figures for labor hiring for the different sample strata are available. Generally, the question of labor, important as it is, is not thoroughly treated in the farm management reports.

Gross margins per man-day (in Figure 4) are highest for the top third crop farms, except in 1981 where the middle crop farms had the highest gross margin per man-day. This may have been an interaction of labor with good rainfall or higher total labor for the middle third farms. However, in Figure 5, gross margin per hectare are clearly highest for the top crop farms and lowest for the bottom third crop farms.

From the above figures, it can be inferred that small areas planted with high labor use per hectare results in high yields per hectare. This is because yields per hectare seem to be very sensitive to labor

Table 5.4. Labor Utilization of Average Farm By Type of Enterprise.

	Unit	1977/78			1980			1981		
		Crops	Livestock	Total	Crops	Livestock	Total	Crops	Livestock	Total
Total Labor	M.D. ¹	111	174	285	99	142	241	71	133	204
Family Labor	Percent	84	81	82	90	79	83	89	76	80
Hired Labor	Percent	16	19	18	10	21	17	11	24	20

Table 5.5. Gross Margin Per Man-Day of Selected Crops by Sample Stratum.

	1977/78						1980						1981					
	Top		Middle		Bottom		Top		Middle		Bottom		Top		Middle		Bottom	
	1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop	
	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.	Farms	Pula/M.D.
Sorghum	0.77	1.13	0.72	0.72	0.20	0.20	1.66	3.18	1.48	1.48	0.72	0.72	2.21	3.12	2.35	2.35	0.93	0.93
Maize	1.16	2.07	0.82	0.82	0.80	0.80	1.45	2.00	1.81	1.81	-0.21	-0.21	3.08	3.08	3.98	3.98	1.40	1.40
Beans	1.02	1.67	0.71	0.71	0.58	0.58	1.20	1.14	1.46	1.46	0.88	0.88	1.78	2.03	1.82	1.82	1.48	1.48
Sunflower	0.76	1.88	0.57	0.57	0.31	0.31	0.09	-0.80	1.34	1.34	-1.07	-1.07	-	-	-	-	-	-
Millet	0.96	1.74	0.52	0.52	0.36	0.36	3.17	3.91	2.04	2.04	0.55	0.55	2.59	3.58	2.17	2.17	1.96	1.96
Watermelon	-	-	-	-	-	-	-	-	-	-	-	-	9.83	8.80	17.19	17.19	5.81	5.81
Sweet Reed	-	-	-	-	-	-	-	-	-	-	-	-	2.31	1.74	5.93	5.93	1.87	1.87
Ground Nuts	-	-	-	-	-	-	-	-	-	-	-	-	1.55	2.29	1.12	1.12	0.59	0.59
Average	0.88	1.47	0.68	0.68	0.37	0.37	1.57	2.52	1.59	1.59	0.35	0.35	2.68	2.92	3.12	3.12	1.40	1.40

Table 5.6. Gross Margin of Selected Crops By Sample Stratum.

	1977/78						1980						1981					
	Top		Middle		Bottom		Top		Middle		Bottom		Top		Middle		Bottom	
	1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop		1/3 Crop	
	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.	Farms	Pula/Ha.
Sorghum	14.79	33.52	13.68	13.68	2.33	2.33	39.12	80.82	37.91	37.91	14.02	14.02	30.56	73.53	36.26	36.26	7.78	7.78
Maize	12.00	25.88	8.30	8.30	7.49	7.49	15.14	33.13	18.98	18.98	-1.26	-1.26	45.82	73.58	46.13	46.13	11.38	11.38
Beans	19.20	43.68	11.82	11.82	6.13	6.13	17.05	18.44	19.94	19.94	11.24	11.24	33.46	42.05	36.42	36.42	22.47	22.47
Sunflower	7.52	19.31	6.75	6.75	2.27	2.27	0.47	-2.02	8.38	8.38	-6.40	-6.40	-	-	-	-	-	-
Millet	22.55	35.76	14.34	14.34	6.79	6.79	69.07	97.69	34.07	34.07	9.58	9.58	62.61	125.34	55.42	55.42	29.66	29.66
Watermelon	-	-	-	-	-	-	-	-	-	-	-	-	128.80	227.29	218.29	218.29	41.24	41.24
Sweet Reed	-	-	-	-	-	-	-	-	-	-	-	-	31.46	89.89	65.85	65.85	3.36	3.36
Ground Nuts	-	-	-	-	-	-	-	-	-	-	-	-	57.86	120.00	34.10	34.10	19.57	19.57
Average	14.96	34.51	11.34	11.34	4.17	4.17	29.33	57.22	28.62	28.62	7.68	7.68	40.61	72.26	45.73	45.73	13.13	13.13

¹ M.D. = Man-day or eight man hours per day.

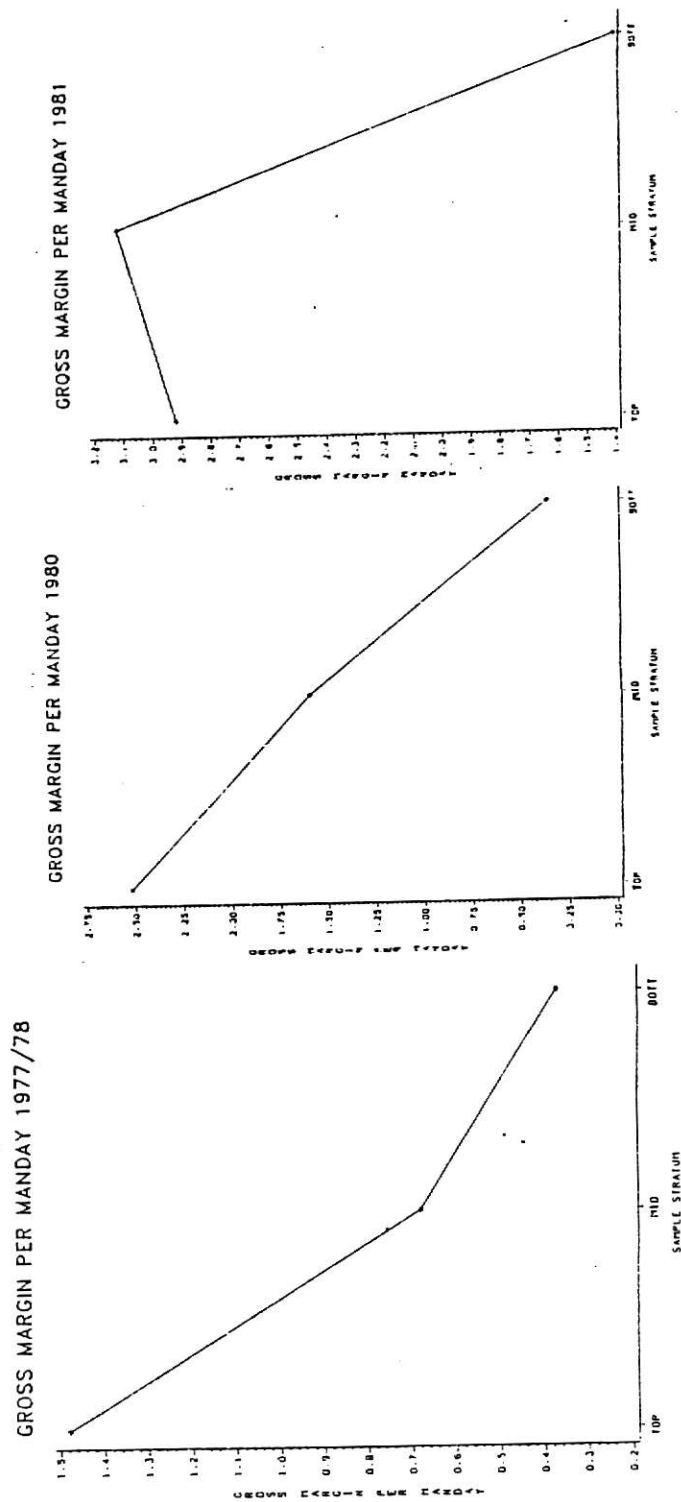


Figure 4. Average Gross Margin Per Man-day by Sample Stratum for Years 1978, 1980, and 1981.

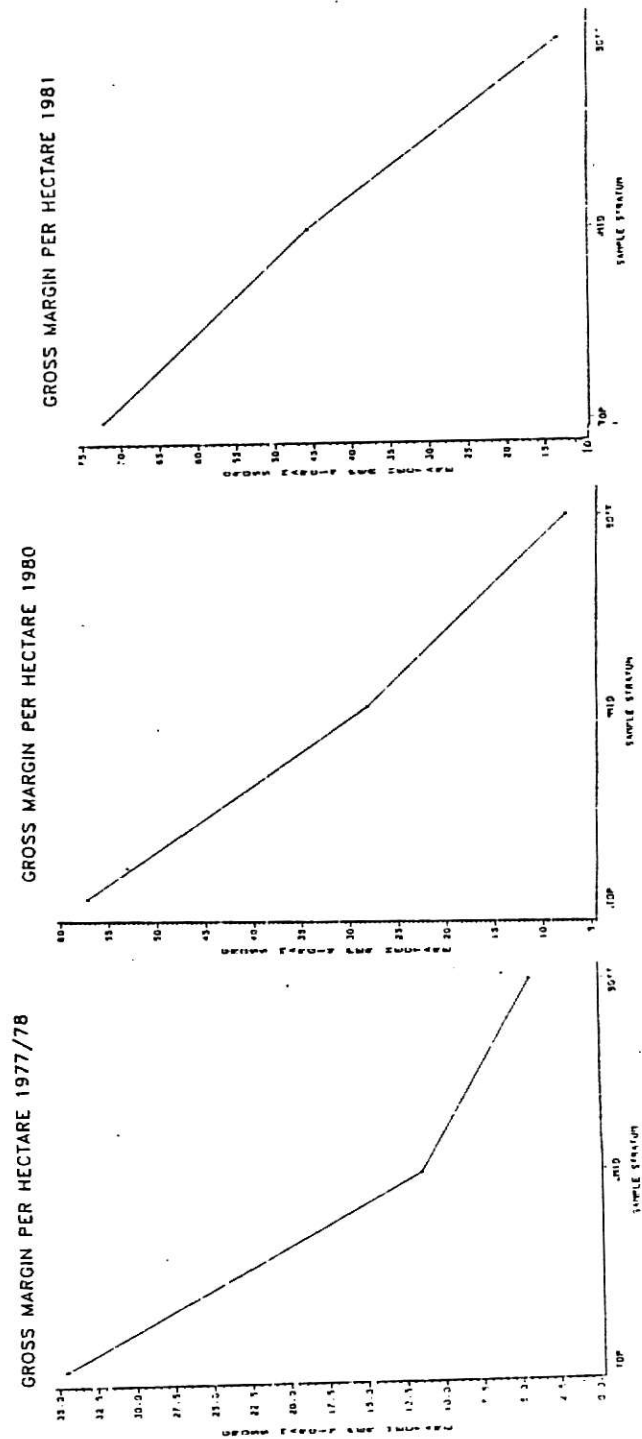


Figure 5. Average Gross Margin Per Hectare by Sample Stratum for Years 1978, 1980, and 1981.

use per hectare. This is clearly shown in 1981, where both yields per hectare dropped greatly by sample stratum, similar to the drop in labor use per hectare by sample stratum. From the above figures, it is also worth noting that the top one third farms have highest yields per hectare (KG/Ha), highest gross margin per hectare (Pula³/Ha), highest gross margin per unit labor (Pula/Ha), and they plant small total hectarages. This tends to facilitate high productivity due to intensity of labor per hectare resulting in high yields per hectare and high gross margin per hectare, per man-day, and total gross margins.

Livestock production has been said to be more profitable and less risky because of the relatively high drought adaptation of livestock than crops in general. But there also seems to be some farms that are performing poorly in livestock production. The farm management classification into top third, middle third, and bottom third shows that the bottom third livestock farms are non profitable. There may be many causes, including poor husbandry practices, below optimal cattle holdings, or insufficient investment in the livestock farms. It is important to study in detail, the differences between these three sample strata on their livestock production systems.

Livestock production is an important activity for many traditional farms, its role on farming such as draft power provision, income, and milk production for the farm has been reviewed. However, production of two products from the same input may not be possible without competition for resources. It seems that although crop farming and livestock production may complement each other, there may also be competition for labor and capital. If hectarages are too large, a tradeoff may have to

³Pula is the Botswana currency. 1 Pula = \$0.94.

be made at the expense of livestock production, otherwise hiring of labor may be necessary. From the indication of the Farm Management Reports there may be competition between cattle and cattle production, particularly in terms of labor and capital. Best crop farms tend to be poor livestock farms and vice versa.⁴

Tables 6.1a and 6.1b show the performance of the farm management survey farms in their livestock enterprises. The top third crop farms tend to have a low off take rate⁵ and the highest birth rate, and the bottom third with the highest death rate.

Figures 6 through 10, show the relative performance of these three sample strata for the years 1980 and 1981. For some reason the top third farms seem to have higher or the same cattle death rates as the middle third livestock farms. The data on the livestock farms is not as clear as the crop farm data. It is therefore, difficult to make realistic implications from these results.

From Figures 11 and 12 the top third livestock farms are better in terms of total gross margin and gross margin per livestock unit, followed by the middle third livestock farms. One important measure of the performance is labor. This is not shown for livestock farms. The labor use would reflect some aspects about the management of the three sample strata. It is rather interesting to note, despite the low offtake rate of top third farms, they have the highest total gross margin and gross margin per hectare. These characteristics cannot be explained on the basis of the data as reported in the farm management

⁴ Farm Management Survey 1980. page 12.

⁵ Off-take rate is the number of animals sold, gifted out, and home consumed during a year divided by the total animals owned.

Table 6.1(a) and (b). Average Birth, Death, Offtake³ and Herd Growth Rates, by Type of Livestock and Sample Stratum, 1980 and 1981.

6.1(a) 1980

9.1(a) 1980

	All LS ²	Top 1/3 LS	Middle 1/3 LS	Bottom 1/3 LS
	Farms	Farms	Farms	Farms
	(-----Percent -----)			
<u>Cattle</u>				
Birth Rate	36.6	48.8	37.9	29.9
Death Rate	9.6	10.4	4.6	12.5
Offtake Rate ³	4.3	3.6	5.8	2.6
Herd Growth Rate ¹	2.8	4.0	7.1	-4.4
<u>Sheep</u>				
Birth Rate	92.3	73.1	126.7	84.6
Death Rate	49.5	14.4	37.3	84.0
Offtake Rate	13.3	2.1	2.7	26.7
Herd Growth Rate ¹	-12.5	40.0	20.6	-50.0
<u>Goats</u>				
Birth Rate	75.5	80.6	79.6	63.2
Death Rate	23.4	13.2	29.9	25.5
Offtake Rate	5.8	2.3	8.6	4.9
Herd Growth Rate ¹	14.1	30.5	8.4	5.9

6.1(b) 1981

	All LS ² Farms	Top 1/3 LS Farms	Middle 1/3 LS Farms	Bottom 1/3 LS Farms
	(-----Percent -----)			
<u>Cattle</u>				
Birth Rate	42.1	46.1	45.8	29.6
Death Rate	4.5	2.7	1.5	12.2
Offtake Rate	5.5	4.8	6.4	4.9
Herd Growth Rate ¹	10.8	15.6	12.9	-1.1
<u>Sheep</u>				
Birth Rate	80.4	96.4	56.5	56.2
Death Rate	15.8	13.7	20.2	19.4
Offtake Rate	8.4	4.6	13.5	12.9
Herd Growth Rate ¹	20.9	38.0	-6.5	0.0
<u>Goats</u>				
Birth Rate	60.0	70.0	56.1	51.2
Death Rate	14.4	9.7	14.9	21.6
Offtake Rate	5.9	2.5	7.7	6.1
Herd Growth Rate ¹	13.1	24.2	8.0	2.7

¹ Change in the number of animals on farm during year.

² L.S. = Livestock Farms.

³ Offtake = the number of animals sold, gifted out, and home consumed during a year.

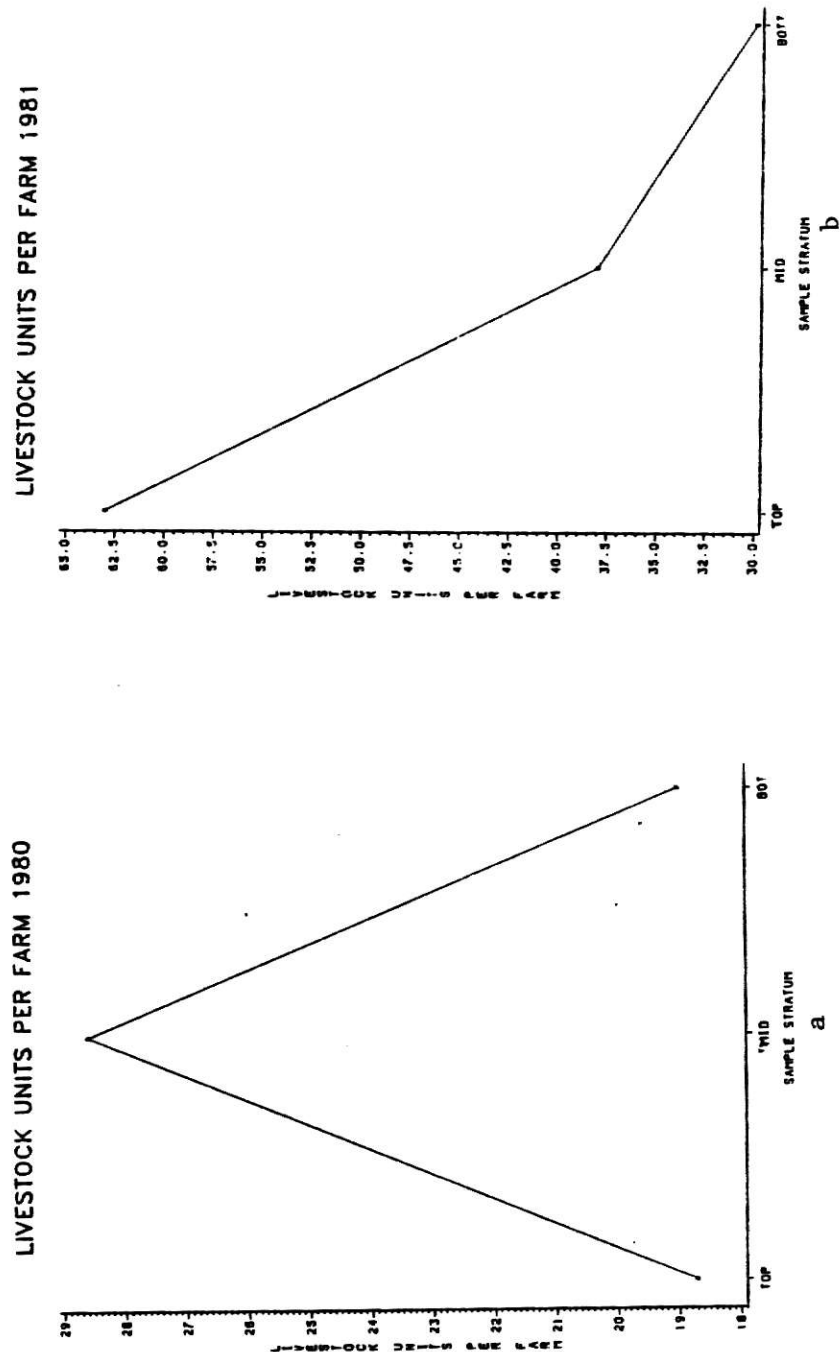


Figure 6. Average Livestock Units Per Farm By Sample Stratum for 1980 and 1981.

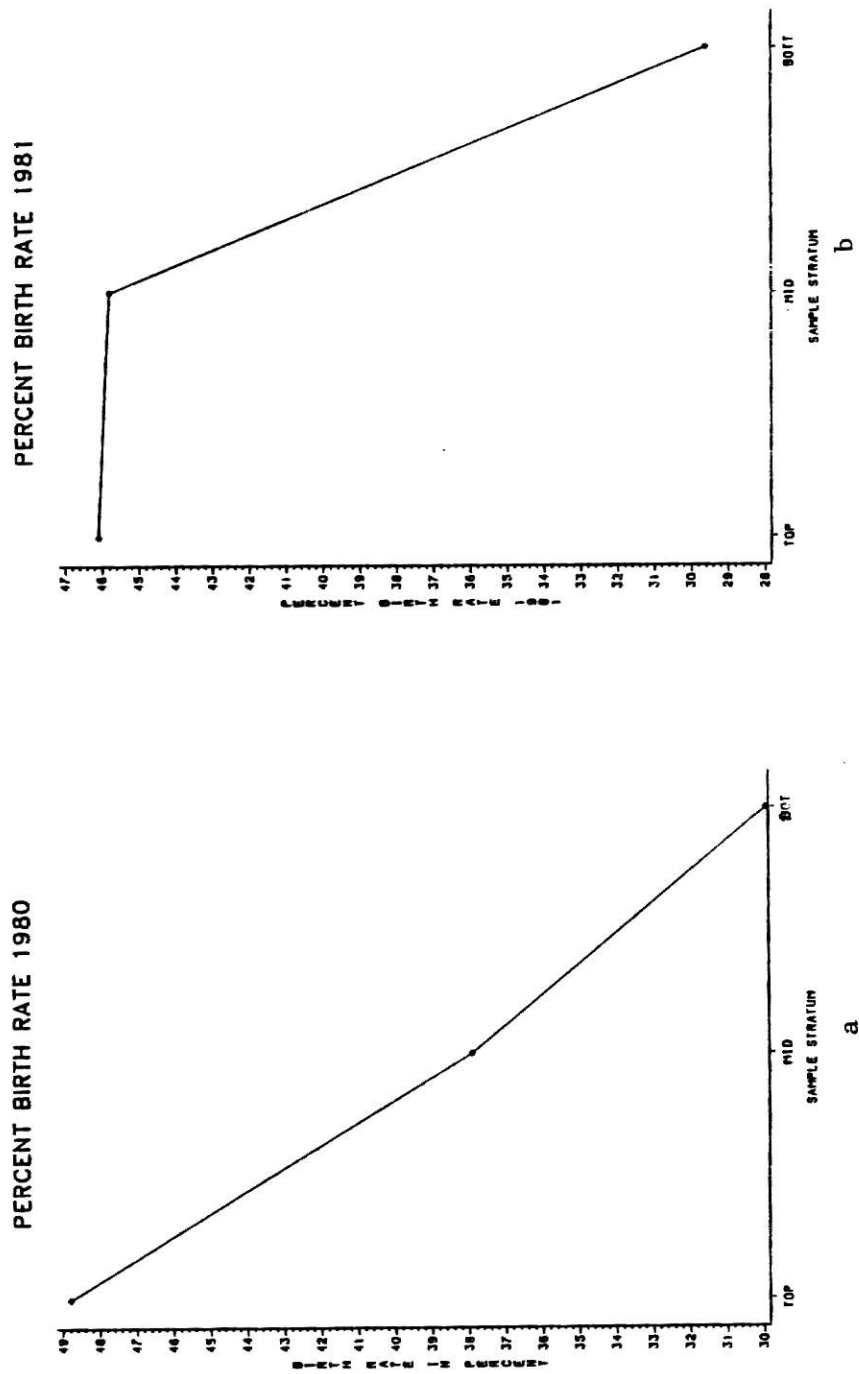


Figure 7. Average Percentage Birth Rates for Cattle By Sample Stratum in 1980 and 1981.

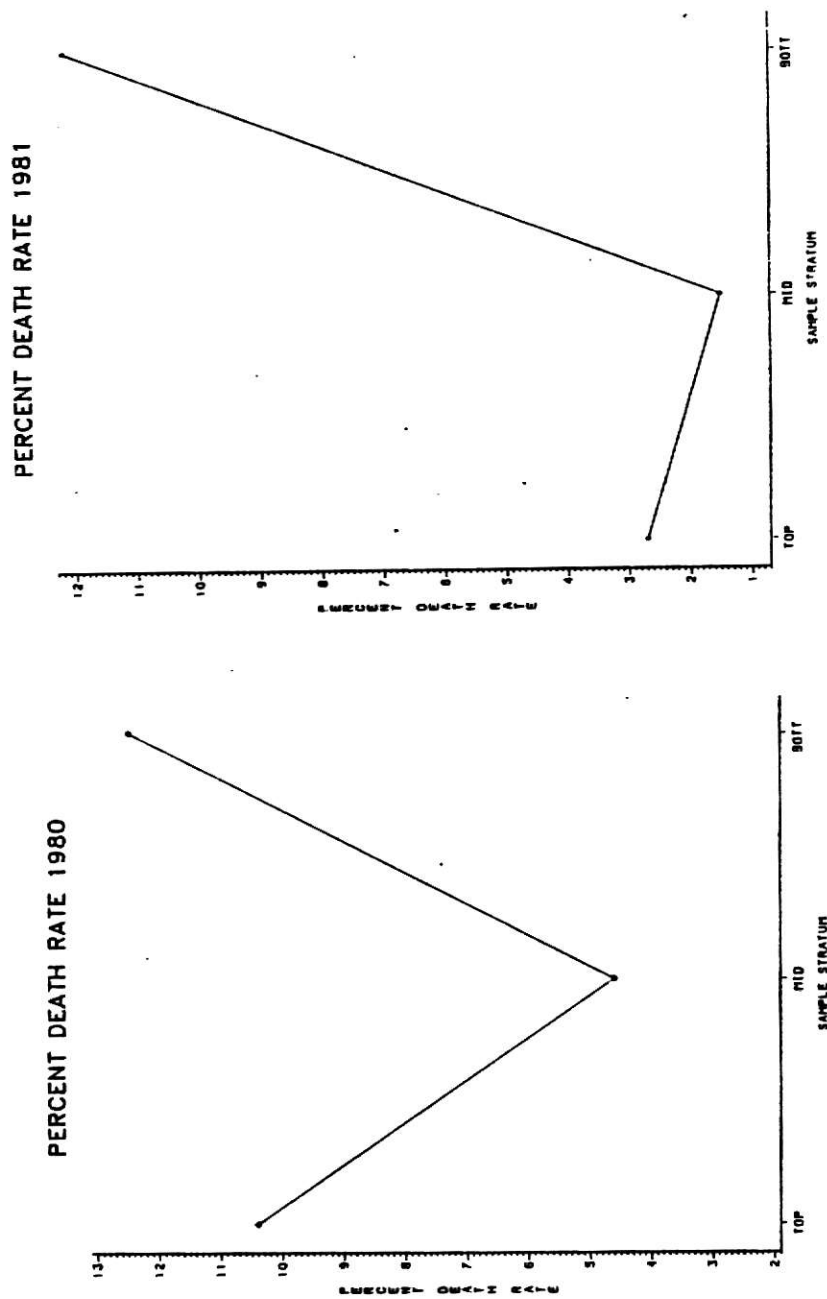


Figure 8. Percentage Death Rate by Sample Stratum For 1980 and 1981.

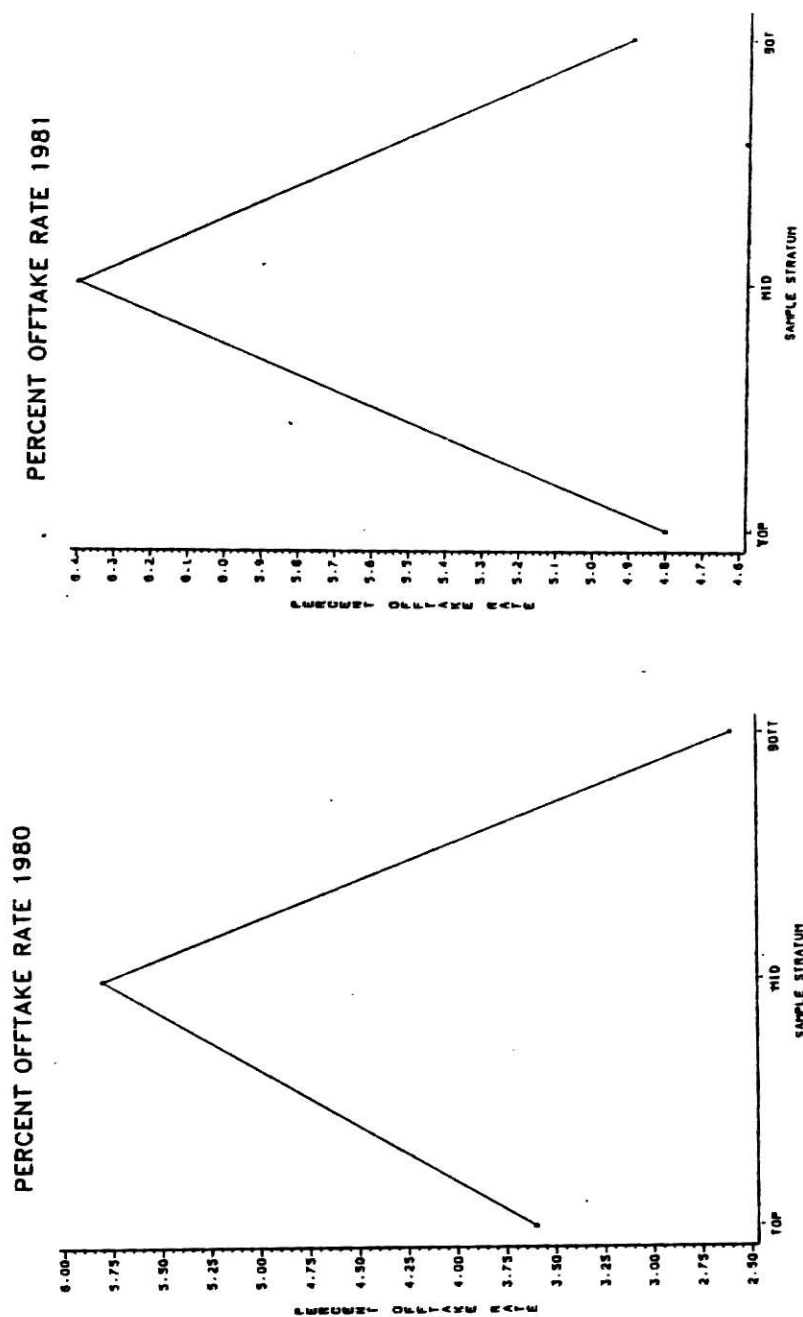


Figure 9. Percentage Offtake¹ by Sample Stratum for 1980 and 1981.

¹Offtake is the number of animals sold, gifted out, or home consumed in a year.

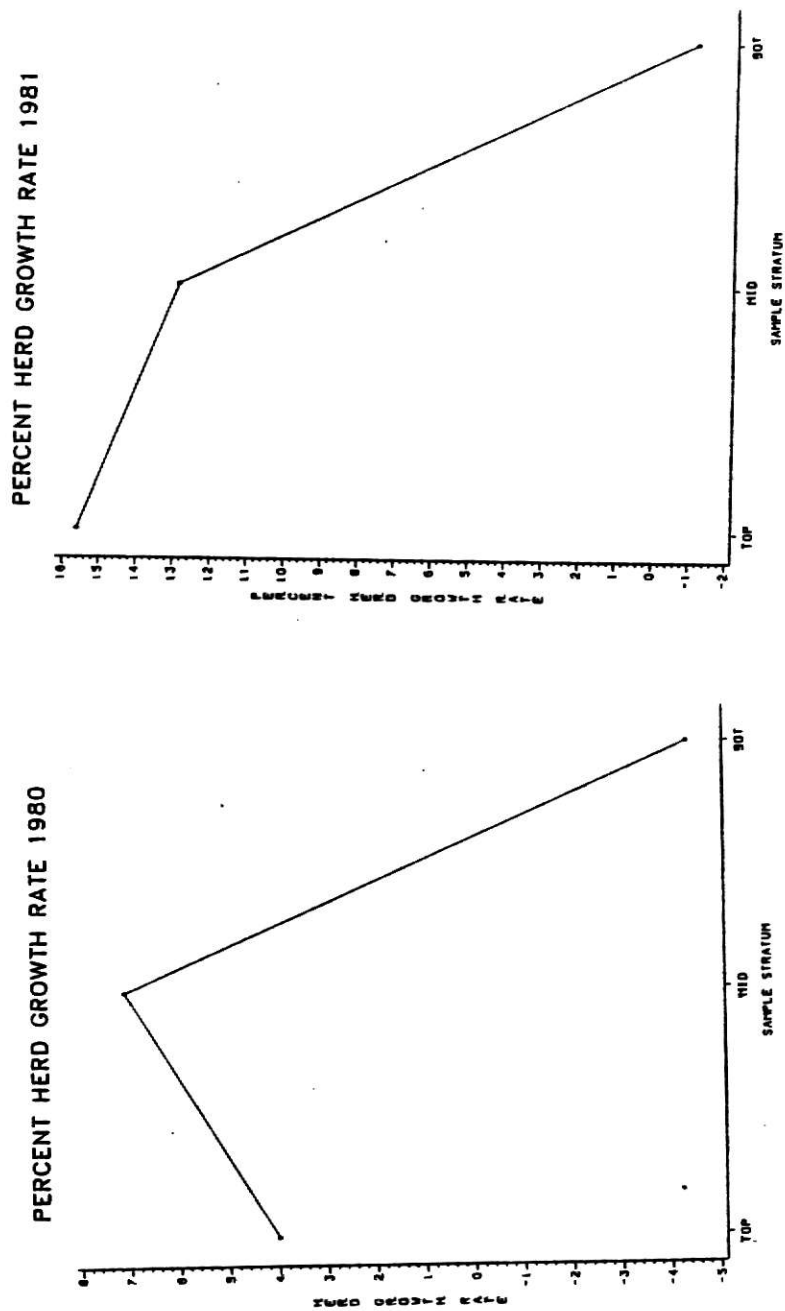


Figure 10. Percentage Herd Growth Rate by Sample Stratum for 1980 and 1981.

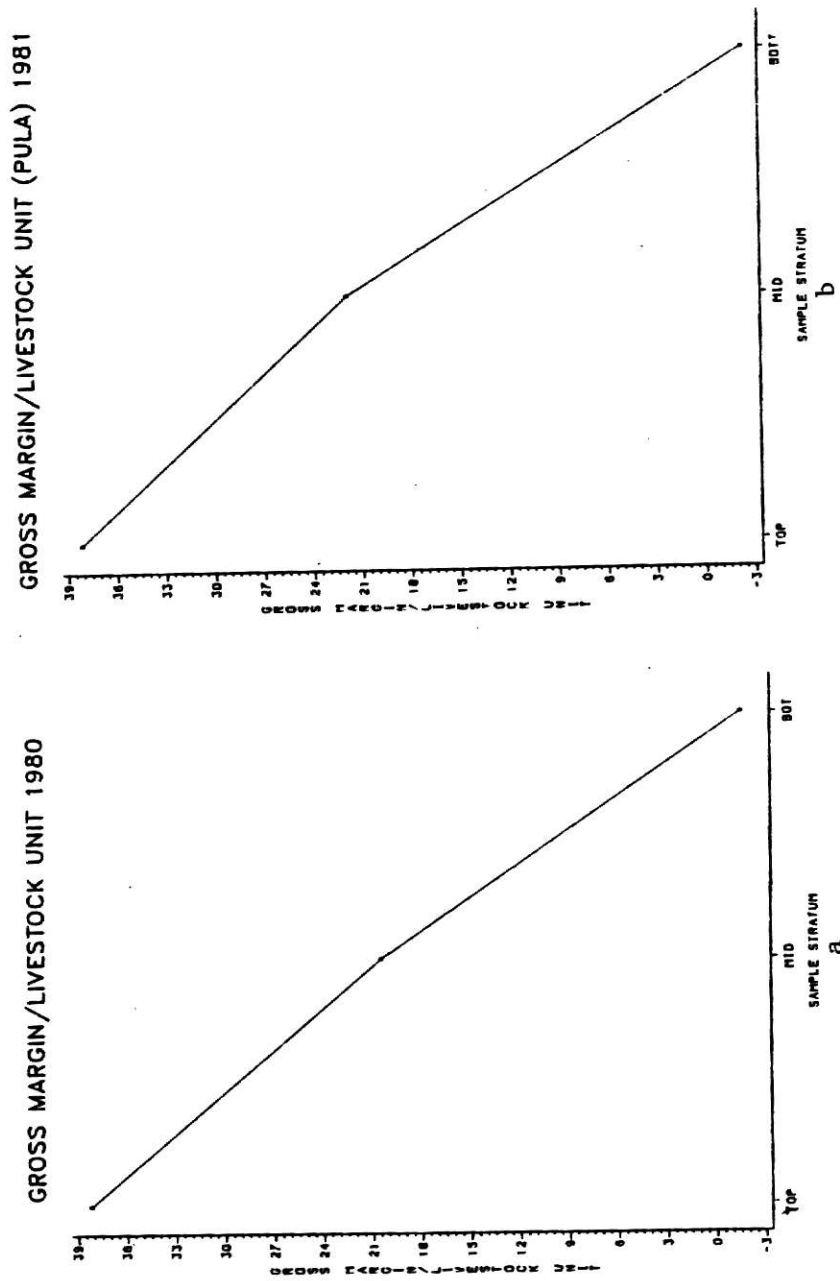


Figure 11. Gross Margin Per Livestock Unit by Sample Stratum for 1980 and 1981.

1 Pula = \$ 0.94.

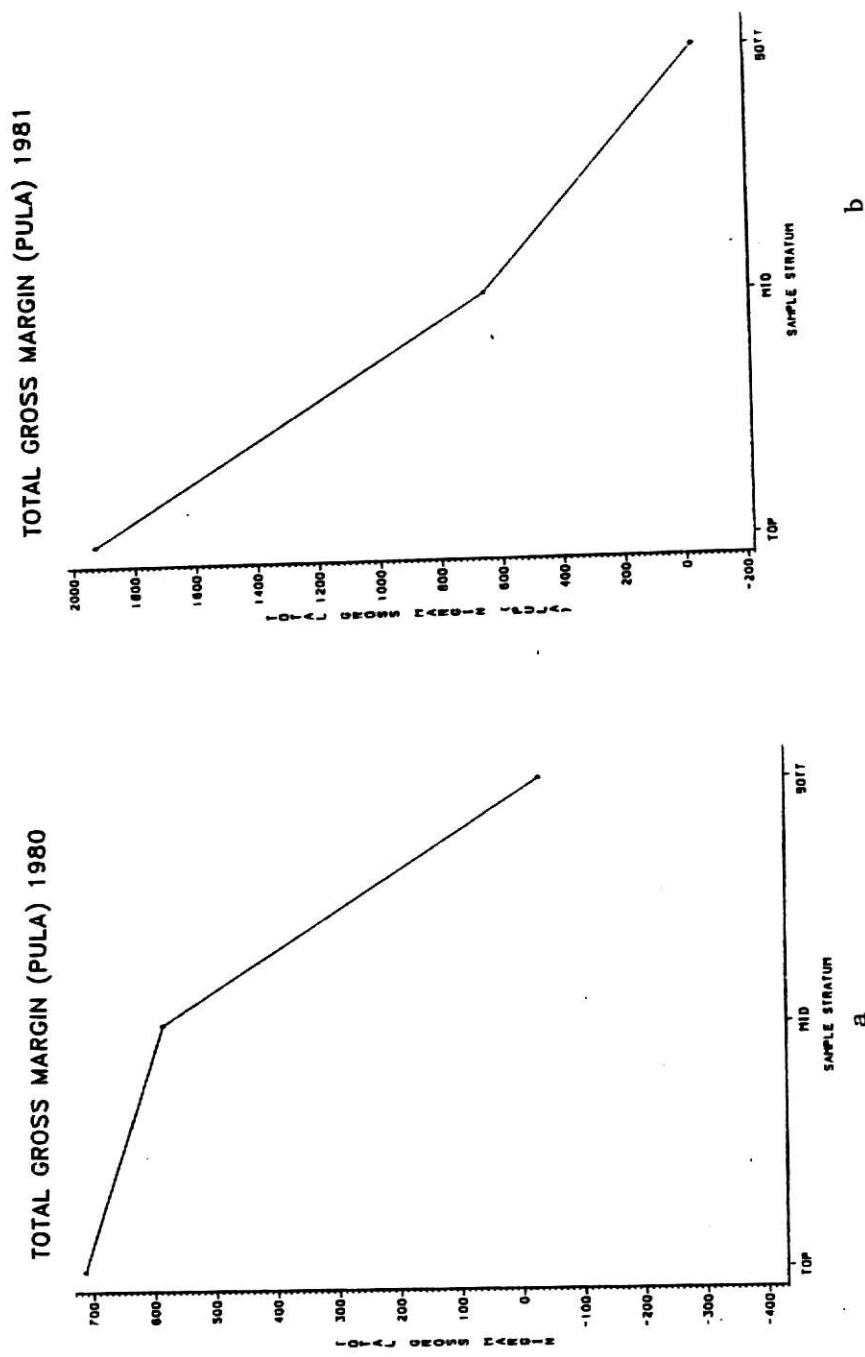


Figure 12. Total Gross Margin by Sample Stratum for 1980 and 1981.

1 Pula = \$ 0.94.

Table 7. Farm Income Per Farm and Livestock Unit by Type of Livestock and Sample Stratum for 1980 and 1981.

	<u>1980</u>			
	All Farms	Top Livestock Farms	Middle Livestock Farms	Bottom Livestock Farms
<u>Cattle</u>				
Animals Per Livestock Farm	29	25	37	25
Livestock Units Per Farm	22.2	18.7	28.6	19.0
Total Gross Margin (Pula)	424.09	713.56	584.14	-30.44
Gross Margin Per L.U. (Pula)	19.10	38.16	20.42	-1.60
<u>Sheep</u>				
Animals Per Livestock Farm	1	1	1	1
Livestock Units Per Farm	0.1	0.1	0.1	0.1
Total Gross Margin (Pula)	0.10	3.86	2.79	-6.12
Gross Margin Per L.U. (Pula)	1.90	38.60	34.88	-30.60
<u>Goats</u>				
Animals Per Livestock Farm	11	11	13	10
Livestock Units Per Farm	1.3	1.2	1.5	1.2
Total Gross Margin (Pula)	32.74	48.80	33.20	16.19
Gross Margin Per L.U. (Pula)	25.18	40.67	22.13	13.49
<u>1981</u>				
<u>Cattle</u>				
Animals Per Livestock Farm	51	75	41	37
Livestock Units Per Farm	44	63	38	30
Total Gross Margin (Pula)	849.12	1928.39	645	-54.45
Gross Margin Per L.U. (Pula)	24.47	38.19	21.88	2.38
<u>Sheep</u>				
Animals Per Livestock Farm	9	22	4	6
Livestock Unit Per Farm	0.2	0.3	0.1	0.1
Total Gross Margin (Pula)	8.68	18.65	3.91	3.23
Gross Margin Per L.U. (Pula)	43.40	62.14	39.10	32.30
<u>Goats</u>				
Animals Per Livestock Farm	19	24	18	15
Livestock Units Per Farm	1.7	1.9	1.8	1.4
Total Gross Margin (Pula)	22.01	40.02	13.06	12.51
Gross Margin Per L.U. (Pula)	12.95	21.06	7.26	8.94

L.U. = Livestock Unit
1 Pula = \$ 0.94.

survey reports. Both top and middle third livestock farms tend to have high herd growth rates due to low death rates.

Production systems of the bottom third livestock farms need to be studied more closely, for 1980 and 1981 the bottom third farms had higher death rates, lower total gross margins, and lower gross margin per livestock unit, whereas the top and middle third farms had high total gross margins and gross margin per livestock unit.

FACTORS AFFECTING AGRICULTURAL PRODUCTION

One of the most wanted and scarce resource in Botswana is water. Water resources begin with rainfall which in Botswana is erratic and very marginal. The annual average rainfall of 24.6 inches (650 mm) in the extreme north to less than 9.8 inches (250 mm) in the southwest with a respective coefficient of variation of 30% and 80% for each, thus showing how unpredictable lower rainfall areas are in Botswana. Temperatures are high in Botswana and the evaporation potentiality of 1.8 meters a year, takes a heavy toll.¹ The kalahari sand absorbs most rainfall water, consequently there are no rivers in the west. Rainfall results in river flows only in the east and these rivers are almost all ephemeral, flowing from a few days a year (or not at all) to several months. The total flow of these rivers within Botswana is of the order of 700 million cubic meters annually, but very variable. The construction of dams to harness these rivers is not in most cases possible without large dams, which are very expensive. There is, however, a small scale extraction from sandy river beds. The Limpopo River, the largest river in Botswana, forms part of Botswana's eastern border and is a potential water source, however, its development will have to involve South Africa.

Another source of water is ground water with typical depth from 98 feet to 330 feet (30 m to 100 m) in Eastern Botswana. For example, there are about 5,000 boreholes in Botswana. The water demand is great in all the four major types of water use, urban and mining, major villages, small villages, livestock watering, and scattered settlements

¹National Development Plan, Ministry of Finance and Development Planning. November, 1980, Page 171.

in cropland areas, and irrigation. It seems that all these water demands are currently not fulfilled and the demand is still growing. In fact, water is so important to Botswana because of its many uses, households may not move to the croplands if there is no water at the croplands and if there are no means to haul water to the lands for domestic use. Because farmers do not move to croplands, agricultural activity is delayed. Low rainfall years are characterized by little or no crop output and major losses in livestock enterprises in the form of cattle deaths, weight loss making them of lower quality at sales and making cattle unable to plough during the cropping season. Nationwide prayers are even held to pray for rain since rainfall is known to determine the livelihood of Botswana.

The Okavango Delta is another alternative source of water for Botswana. Most important it has irrigation potential for that area. Currently few dams have been constructed, but it is increasingly apparent that water sources must be developed.

Some irrigation is undertaken in Botswana, particularly in the Tuli Block freehold farms bordering the Limpopo River with South Africa. The potential for irrigation in Botswana exists at the Okavango Delta and the Limpopo River and some of its tributaries. Because the terrain in Botswana is flat, irrigation will first require great capital investment in construction of large dams, and resources are currently unavailable. Even if capital resources were available it seems water demand for urban and mining, major and small villages, and livestock watering have high priorities and will be satisfied before dams for irrigation can be envisaged. This is not to under-estimate the importance of irrigation in Botswana. Irrigation would particularly be lucrative in horticultural crops in Botswana, an alternative that is potentially viable.

It has to be mentioned that dams would reduce the heavy erosion from the already poor soils, resulting from the controlled grazing, (communal grazing), uncontrolled rivers, and from the type of rainfall (which is high intensity, short duration type) that occurs. These eroding soils also cause substantial yield deterioration. Obviously, the marginal rainfall itself and its poor distribution make it very risky for rain-fed farming. This is the condition under which traditional crop production is practiced, it is risky, unreliable, and difficult. Even on the livestock side, boreholes and wells sometimes do dry up due to insufficient replenishment from the rainfall and the pastures are often not available where water is available.

One factor worth noting is the South African neighborhood influence. Botswana shares borders with the Republic of South Africa and migration to South Africa has for a long time been an important fact of life in Botswana. Labor migration has primarily consisted of able-bodied men migrating for wage employment, thus providing both secure employment and income, which are important for the economic well-being of the migrants. Many migrants were recruited for employment as mine laborers in the South African mines. This migration has had several secondary impacts upon rural Botswana. Because of migration of a large proportion of able-bodied men, available acreage could not be adequately plowed and planted, resulting in lower yields. Incomes earned from wage employment in the Republic of South Africa (RSA), have affected agricultural incentives. The result has been less dependence upon agriculture for a livelihood and little incentive to invest in agriculture. Again because crop production is riskier and the returns are less compared to

wages earned from the RSA mines. Consequently, crop production and practices of most farmers have remained static, with low yields and returns. However, since the down turn of the Republic of South Africa recruitment in 1977 of mine workers from Botswana,² it is likely that investment agriculture will increase. Because of the sharp fall in the recruitment and the continuous decline in recruitment, alternative economic activities will have to be embarked upon by migrants. Whereas, the incomes of many rural dwellers will be reduced by this trend, it has also been noted that migration has severe negative impacts on families, village life, and development efforts. Also a small proportion of incomes from the RSA have been invested in agriculture.³ A study conducted in Lesotho seems to confirm that because of high wages in South Africa, agriculture has not been able to compete successfully both in Botswana and Lesotho. Agriculture in the past was mainly undertaken by women and young men (before they are grown to be male workers) and quite elderly men and this rendered it as a secondary activity in terms of income earned. Most people leave home only when their need for food or income becomes acute.⁴ The peak in migration is in May when the effects of crop failure itself are first experienced.⁵

²National Development Plan 1979-85. Ministry of Finance and Development Planning. Page 19.

³International Labor Migration: The Case of Lesotho. Plath, J. D., and Carvalho, J. W. Paper presented in the 1984 American Agricultural Economics Association meeting at Cornell University, August, 1984.

⁴Oland, K., and Cummings, Jr., R. W. Targets for Agricultural Development in Botswana. Department of Agricultural Research, 1980. Ministry of Agriculture. Page 11.

⁵Drought in Rural Botswana: Socio-economic Impact and Government Policy. Vierich, H. and Sheppard, C., Ministry of Agriculture, 1980. Page 54.

the average migrant tends to be a child of a household, aged between sixteen and thirty with no education. On the whole, migration to towns and to South Africa is much higher from the hardveld⁶ than from the sandveld,⁷ possibly because of higher population density in the hardveld (East Botswana). Migration has its costs, the risks can be great, and for those with no cattle it may be cheaper and safer to stay in the village.

Rainfall has been singled out as the greatest factor in determining yields. The below optimal rainfall for crops has great negative impact on the yields. There are marked increases in yields per hectare and overall total yields, when the rainfall increases. The increase in the amount of rainfall increases the amount of area ploughed/planted. Small amounts of rainfall results in less area ploughed/planted. Temperatures are high in Botswana, this makes evaporation high and less water is retained in the soil. The type of rainfall, the high intensity short duration type, results in more water running off and less percolating in the soil and also causes soil erosion. Given these high temperatures and less water infiltrating in the soil from any given rainfall, less areas are ploughed since the moisture doesn't stay long enough for ploughing. Again the majority of farmers use cattle draft power which do not plough large areas per day. The results are really disadvantageous during the below normal rainfall years. This does not include

⁶ Hardveld are mostly hard, clod farming, with high natural bulk density and tendency to surface capping found in Eastern Botswana.

⁷ Sandveld, Kalahari sands that cover about 60-70% of the country, mainly in west and southwest part of Botswana.

the fact that the rainfall is sub-optimal. When we consider the effect of insufficient moisture conditions for the crops themselves, the effect is even greater. It is very normal to have zero yields in below normal rainfall years, particularly on crops sensitive to moisture conditions, like maize.

Map 2 shows annual rainfall in millimeters and percentage of seasonal variability of the rainfall in Botswana. It is important to note that the map shows that over half of the country have a seasonal variability of rainfall of 50 percent and above.

The Dryland Farming Research trials in 5 locations in Botswana of sorghum on relatively similar soils showed that most yearly variations in yield were essentially due to the difference in the amount and distribution of moisture in the soil profile at planting time. In maize nearly 70 percent of the variance of mean maize yield was accounted for by rainfall.⁸ The linear regression showed that yields of 1 ton per hectare or greater requires a rainfall of at least 325 millimeters during the growth period, and when rainfall has been less than 200 millimeters, yields have been negligible.

Another aspect of rainfall does seem to be very important in Botswana. The rainfall distribution affects the area ploughed/planted, the yield itself, and the total production. Under poor rainfall distribution, total area ploughed/planted, yield and total production do seem to be reduced. Poorly distributed rainfall results in small hectarages ploughed/planted. This is mainly because optimal moisture conditions do not stay long in the soil due to high temperatures making time for ploughing/planting small, also because 70 percent of traditional

⁸ Annual Report for the Division of Arable Crops Research 1981-82.
Department of Agriculture Research. Ministry of Agriculture, August,
1983. Page 168.

households use cattle and donkeys to plough/plant. These are really fairly slow means of ploughing/planting. Therefore, by the end of the ploughing season, very few hectares have been planted. The other impact of poor rainfall distribution is on the yield itself, particularly on drought susceptible crops like maize. Its plant growth, yields, and yields per hectare are depressed. As a direct result of the few hectares planted, total hectareage planted becomes small and hence total production, country wide, becomes small and insufficient. An examination of rainfall should take into account its distribution to evaluate its effects on production. Rainfall may seem sufficient from the total rainfall figures, yet yields and total production are very low, like in 1977/78 and 1978/79 cropping seasons, mainly due to poor rainfall distribution within the cropping season.

The planting date factor has been one of the controversial factors since no single date has been associated consistently with high yield results. The optimum planting date has not been accurately and satisfactorily determined in Botswana for the different crops. Generally, November ploughing/planting is considered early, December middle, and January late ploughing/planting. Some studies, however, have recommended November 12th as the first day to start planting to about the end of November as the optimum planting date. This date is still, however, very controversial. Some farmers spread their planting date between early, middle, and even late planting (November, December, January) respectively, as a risk aversion strategy. Planting date is influenced by the timeliness of rainfall (whether rains come early or late),

draft power availability. Different years seem to have their own unique planting time for optimum yields. However, early planting is generally recommended. Although there is no clear indication of the right planting date, timeliness does seem to be an important factor, particularly in relation to the total area planted. This option may be open to those who own their draft power, but those at the end of the line who have to borrow or hire on the open market may have to plough when the draft power is available, rather than when the planting conditions are favorable. Those farmers owning the means of ploughing/planting are better able to plant at both right moisture conditions and recommended planting dates.

The problem of agricultural production needs to be considered under some perspective. A look into the agricultural statistics seems to show some indicators accounting for the current production levels, if not the fundamental source of the problem. On the basis of the available data, the whole traditional sector in Botswana indicates characteristics that may explain the underlying problems behind the traditional agricultural sector.

Production (crop) per farm increases with the number of cattle in the household, i.e., cattle and crop production are complementary for many traditional farmers. Cattle ownership enhances timely ploughing/planting. The average yield per hectare increases as the number of cattle per farm increases. Adequate ownership of cattle increases productivity since timely planting is possible. The smaller the hectareage the smaller the ratio of area harvested to area planted, i.e., as hectareage increases the percentage of area harvested to area

planted increases. It is highly likely that farmers ploughing small hectarages are resource poor, own less cattle, plough in the latter part of the planting season, and hire cattle or tractors. As hectarage increases per farm, the ratio of farms harvested also increases. About 50 percent of farmers growing 0.1 to 1.0 hectare leave their land or abandon their land or only 50 percent of very small farms ploughed/planted are actually harvested.⁹ Hiring or lack of draft power results in late ploughing/planting which tends to result in crop failures.

Many traditional farmers (78%) realize low yields per hectare and few realize high yields per hectare. This may be a result of the fact that very few (50%) farmers own adequate cattle to serve as a source of draft power. This is a result of the uneven ownership of cattle in Botswana. Herd sizes may not provide the needed draft power causing small areas ploughed/planted or even late ploughing/planting. It has been stipulated that cattle herd sizes of about 20-30 cattle usually barely provide the needed draft power.¹⁰ This correlation between low yields and small cattle herd sizes is observed from the fact that many households actually own small cattle herds. Cattle draft power is still an important source of draft power. Afterall, 70 percent of the ploughing/planting is done by cattle draft power, followed by tractor power and donkey/mule draft power, which accounts for the remaining 30 percent of traditional sector ploughing/planting.

⁹1979-1981 Botswana Agricultural Statistics. Ministry of Agriculture Botswana.

¹⁰Vierich Helga. Drought, 1979, Socioeconomic Survey of Drought Impact in Kweneng. Ministry of Agriculture, Botswana.

Since livestock production is an integral part of the farming system, it would be inadequate to study the overall crop production without a brief analysis of the traditional livestock sector. The herd composition of the traditional sector has a high percentage of oxen, particularly for small herd sizes and the percentage tends to get smaller with larger herd sizes. This seems to reaffirm the contention that cattle are kept to secure draft power needs for the household in addition to their saleable potential. Past studies have indicated that cattle are kept as a store of wealth by the traditional societies,¹¹ this speculation seems to lack the details on why cattle are kept by farmers. Cattle provide draft power services, milk, and can be marketed. Therefore, to those households with small herds (less than 20 cattle) the goal seems to be to build up the herd to assure draft power requirement needs for crop production. The crop production in such cases is an extremely important activity to attain the goal by having less reliance on the cattle for food needs. It is important to realize that 47% of the traditional cattle farms have herds of 20 and below and these herds are generally inadequate to provide draft power. Added to these, there are those who do not own cattle or donkeys and rely on those farms with draft power for their ploughing/planting.

It has also been observed that farms with highest per hectare income from crops (high yields) tend to have lower income per livestock unit from livestock activities (few livestock units kept).

¹¹Doran, M. H., Low, A.R.C., and Kemp, R. L., "Cattle as a Store of Wealth in Swaziland: Implications for Livestock Development and Overgrazing in Eastern and Southern Africa. American Journal of Agricultural Economics. Volume 61, Number 1, February 1979. Page 42.

The same holds true for those farms with greatest returns per livestock unit in that they tend to have the lowest incomes per hectare from the crops.¹² While this disparity may be subject to many explanations, it would seem that farms relatively proficient in crop farming are less so in livestock production and vice versa. It is also possible when resources like labor are scarce that one operation is maintained at the expense of another and usually the one which the household is heavily dependent upon will be maintained. As a result, it is highly likely that farmers intensifying on cattle own large herds and those proficient in crop production own few or no cattle.

Cattle deaths are high for farms with small herd sizes. It is generally true that farms with small cattle herds are relatively resource poorer than farms with large cattle herds. The death ratio decreases with increasing herd sizes, implying that farms with large cattle herds have the needed capital resources rather than the farms with small herds. Farms with small herd sizes have a higher ratio of purchase to total herd, again to build enough cattle herd to secure draft power availability since both yields and yields per hectare both increase as the number of cattle per farm increases. This demonstrates complementarity of the two main activities (crops and livestock). Capital from livestock can be used in cropping activities to purchase seeds, hire labor, plough, haul grain, and the crop yields also lessen the dependence on the livestock production.

¹² 1980 Farm Management Survey. Planning and Statistics, Ministry of Agriculture. Page 12.

From the indications of the Farm Management Surveys, a proficiency for either crops or livestock production has been observed, whereas the Agricultural Statistics draw both herd size and crop yield directly proportional. The two results may not be contradictory, since the Farm Management Surveys only consider the "best" farmers for either crops or livestock, and these may not reflect the general trend since it is based on a relatively small sample. The general agricultural statistics reflect the convenience of cattle ownership for timely ploughing. In addition, the Farm Management surveys show that those farmers best in management of cattle are less so in crops and vice versa. This is probably because households would generally know the main backbone for the household economy and resources would be targeted to the activity with the best support for the family. Those having many livestock would place more emphasis on tending the livestock and less on crops and vice versa. Because of the uneven livestock ownership, i.e., many households own small herds of cattle, it is likely that most farmers tend to show dependence on both livestock and crops, i.e., most farmers are in the middle group showing no proficiency in either crops or livestock due to their resource limitations. The bottom farms in both crops and livestock were those male and female farmers without adequate draft power.

The stratification by male and female heads of households with adequate and inadequate draft power to identify what the relationships are. Male farmers with adequate draft power had incomes from crops

about double that of females, both in 1980 and 1981 surveys.¹³ Some factors contributing to this difference is that a higher percentage (31%) of female farmers with adequate draft power used tractors compared to male farmers (12%) and inflated the female headed households variable costs. Female headed households also planted smaller hectarages and had lower net incomes (20% less) than the male headed farms. Female headed households also had lower birth and higher death rates in livestock production enterprises.

Female farmers with inadequate draft power had higher incomes from crops than did adequate power draft female counterparts, even though they cropped only about half as much land. Again, the male farmers with inadequate draft power had slightly lower incomes than those with adequate draft power. Female farmers were apparently as efficient in producing crops as male farmers, but are less efficient than their male farmer counterparts in livestock production.

The proportion of female headed households in Botswana is about 30 percent. Women are responsible for and carry out many aspects of crop production and agricultural decision making and in addition they are often responsible for small stock and poultry. About 50 percent of female headed households do not own cattle. Those with no cattle plough/plant late, and consequently tend to have smaller acreages. Again, female headed households are generally considered to face a labor constraint in terms of labor quality, reliability, and quantity.

¹³1981 Farm Management Survey. Planning and Statistics, Ministry of Agriculture, Botswana. Page 17.

The absence of male labor has also a high cost for the household because those activities that are usually done by men in the household in most cases need hired labor to be done, i.e., such as ploughing, fencing, and livestock activities.

Labor, an input that is generally said to be abundant in many third world countries does seem to be lacking in Botswana. Mixed farming, of raising livestock and crops creates labor constraints that adversely affect production. Peak labor demands for livestock coincide with peak labor demand in cropping activities. Labor shortages manifest themselves in lack of timely weeding and other husbandry practices that are done late or not at all, such as deticking in livestock enterprises are postponed to winter seasons when labor demands are less. In so doing, losses or costs are incurred in the livestock enterprises. Again, it is easy to observe that those top one-third of the crop farms invest more labor per hectare and plough less hectarages. Whereas the middle one-third and bottom one-third plough larger hectarages and provide less labor per hectare. Table 8 shows the labor utilization per hectare of the different categories of farms and for the different crops in years 1978, 1980, and 1981. There is considerable variation between labor used per hectare for the three categories and also between the crops. This difference in labor use per hectare probably explains the yield differences. It may be said that low labor use per hectare results implies late weeding and sub-standard performance of other cropping activities.

Table 8. Labor Utilization Per Hectare (M.D. per Hectare) By Crop and Categories: 1978, 1980, 1981.

	1978				1980				1981			
	Top		Middle		Top		Middle		Top		Middle	
	All Farms	1/3 Crop Farms	1/3 Crop Farms	Bottom 1/3 Crop Farms	All Farms	1/3 Crop Farms	1/3 Crop Farms	Bottom 1/3 Crop Farms	All Farms	1/3 Crop Farms	1/3 Crop Farms	Bottom 1/3 Crop Farms
Sorghum	19.2	29.8	19.0	11.5	23.5	25.4	26.2	19.4	13.8	23.6	15.4	8.1
Maize	10.3	12.5	10.2	9.4	10.4	16.6	10.5	6.0	14.8	24.5	11.6	8.1
Beans	18.8	26.0	16.6	10.5	14.2	16.1	13.6	12.8	18.8	20.7	2.0	15.1
Millet	23.0	20.6	27.7	19.0	21.7	25.0	16.8	17.5	24.2	35.0	25.5	15.1
Watermelon	-	-	-	-	-	-	-	-	13.1	25.8	12.7	7.1
Sweet Reed	-	-	-	-	-	-	-	-	13.6	51.5	11.1	1.8
Ground Nuts	-	-	-	-	-	-	-	-	37.6	52.5	30.5	33.4
Average	17.0	23.5	16.7	11.4	15.8	17.8	16.7	12.9	15.6	24.6	15.9	9.3

SOURCES OF DATA

The data used in this report is from the Farm Management Unit and the Agricultural Statistics Unit of the Ministry of Agriculture. The Farm Management Unit collects yearly farm management survey data from collecting stations established throughout the country. These surveys have been conducted since 1970. The years 1977/78 to 1981 were selected since the data from these years is based on randomly selected farmers and also on a standardized data collection and analysis procedure that allows comparison of results among succeeding years. The surveys prior to 1977/78 cropping season were conducted on very few villages (about four) and few farmers were included in the survey. These farmers were unrepresentative because they were not randomly selected as they were farmer participants of the Pupil Farmer Scheme. These farmers had higher areas ploughed and larger numbers of livestock tended, which were significantly higher than the average farmers. The period chosen is closer to what can be expected in a typical traditional farm (farms with crops and livestock).

The data used in this report is from nine data collection stations. Map 3 shows the locations where the data has been collected. It is observed that all the stations are either in the east, north-east, north, or south-east Botswana regions, where mixed farming (livestock and crops) is common, as a result of higher rainfall. However, in the regression models, only seven locations were used and were mostly in the eastern and north-east locations. In each location fifteen farms are randomly selected and requested to provide the farm management data and

This map illustrates the agricultural extension regional and district boundaries in Botswana. The regions shown include MAUN, FRANCISTOWN, GABORONE, and WESTERN. Key districts and towns labeled are: Tubu, Shakawe, Gumare, Ngamiland West, Ngamiland East, Maun, Kasane, Chobe, Gorokhu, Malobe, Masungu, Francistown, Mmadinare, Selebe-Pikwe, Palapye, Mahalapye, Mmangatlola, Mookane, Gakgato, Palokwe, Barolong, Ngwaketse South, Ngwaketse North, Kweneng North, Kweneng South, Molepolole, Kgalleng, Mochudi, Bamafele/Tlokweng, Gaborone, Kanye, Lobatse, Ngwaketse South, Tahabong, Tahane, Ghanzi, and Gaborone. The map also shows the Central Tlokweng Game Reserve, Central Tlokweng Game Reserve, and Gaborone Game Reserve. A scale bar indicates distances up to 100 kilometers. The map is dated 1971 and is a reproduction of a 1975 edition.

DLU Nov 1979

an enumerator is placed in each location to collect the data.

This source of data was secondary and has not permitted the flexibility that would be otherwise with the use of primary data sources. This has greatly limited the scope of the study and affected the depth of the findings. It has also been difficult to get all the data needed for this study, such as labor use per hectare in various locations. Again the format in which data is summarized makes it difficult to obtain any additional information. The data source is secondary because it is from the reports which have already summarized using other criteria not necessarily consistent to the analytical interest of this report.

Another data source has been the agricultural statistics that were useful in collating and comparing the two data sources and providing the general picture country-wide. Although the data has not been greatly incorporated in this study because of its generality it serves as a useful guideline to the structural and traditional agricultural sector breakdown.

CHAPTER IV

ANALYSIS OF SOME FACTORS AFFECTING YIELD PER HECTARE

Some factors affecting yield per hectare of sorghum, maize, and beans were analyzed using the farm management data obtained at various locations in years 1978, 1980, and 1981. The data somewhat represents averages or aggregates for these locations as approximately fifteen farmers provided the data in each location. The regression variables for the three crops were rainfall, rainfall standard deviation (proxy for rainfall distribution), days after the recommended planting date, average area planted, and the number of livestock tended. Because the data was obtained on a three year period and at several locations, there will be year and location effects. These would be treated as covariates since they would also tend to influence the results. To remove these year and location effects a statistical procedure of general linear model will be used with year and location as class variables in the computation of the regression coefficients.

The rainfall effect has been explained and its link to the production of crops in Botswana. Rainfall is also important in enhancing yields per hectare. Limited rainfall results in insufficient moisture for optimal plant development and this may result in sub-optimal productivity of crops. Actually it seems important to distinguish between the October-January rainfall and the February-March rainfall for most years. The latter is more responsible for yields per hectare than the former which usually determines the area ploughed and less of a determinant of yield per hectare in general. This is because at later stages in plant development good moisture condition becomes even more important for any

harvestable yields to be obtained. However, rainfall and yields per hectare are directly related, particularly environments where rainfall is such a bottleneck.

Some early studies recommended November 12th as the date that ploughing/planting is recommended. It is not clear when the planting time should be and therefore there is considerable differences on whether the above date is the "right" date to start ploughing/planting. Some literature seems to recommend a phasing out of ploughing/planting by November, December, and January as a risk aversion strategy. However, early planting is still the general recommendation of the extension department and Department of Research. From this model it would be interesting to note the relationship between yields per hectare and time of planting. Traditionally sorghum and millet is planted first and then beans and maize later in the growing season. This was due to the long duration of traditional crop varieties. Even the date used in this study does show that beans and maize are generally planted later. Another factor that may influence this is the mid season short drought, which would be more severe to maize than to sorghum relatively.

The rainfall distribution was not provided in the data. As rainfall distribution has been emphasized to impact yields per hectare, a proxy was used to represent the rainfall distribution. The standard deviation for the monthly rainfall served as a proxy for the rainfall distribution. Highly variable rainfall years would have high standard deviation in monthly rainfall and vice-versa. It is logical to understand the negative relationship between variability of rainfall and yields per hectare since crops do need moisture at a constant basis for their development.

Another variable used in this model was the area planted. The area planted may be affected by such factors as late rainfall, quantity of draft power owned, resources for hiring, rainfall distribution, and available labor. A large area planted can cause the spreading out of labor very thinly over the crop farm, particularly if labor is a constraint for subsequent stages after ploughing/planting. This may have a negative impact on yield per hectare when high hectarages are planted with limited amounts of labor.

The number of livestock tended would demand labor and other resources that may otherwise have been diverted to crop production. This may be a negative or positive interaction, as cattle ownership enhances timely ploughing/planting and other operations. If competition for labor exists then it may be reflected on the crop production if the household is highly dependent on cattle.

It has to be stressed once again that because the data is aggregated for about fifteen farmers per location, the variability caused by this factor may not be reflected due to the smoothing due to averages. Another factor which, unfortunately, is not in this data is the labor use per hectare. The data has not been shown for these locations, but it has been shown by this data in a different respect, that labor use per hectare is one of the most important factors of production, even in this dryland farming area. Any farm management report would be incomplete without a thorough coverage of labor use for production.

Due to data limitations and particularly because it is a three year data, it was not possible to do interactions on the model because of few degrees of freedom. Such interactions between livestock tended

and area ploughed, or area ploughed versus planting date, location, and year interactions.

Figure 13 shows the correlation of total grain production with the rainfall. Yearly rainfall fluctuation closely follows the yearly total grain production. This illustrates how rainfall is closely associated with total crop production in Botswana.

Table 9 shows some average rainfall in crop and livestock areas in the whole country. These figures are averages of what is usually very diverse. There are wide differences in rainfall amounts within areas of the same rainfall zone. The reason why cattle areas have less total rainfall is that it also includes areas in west and southwest Botswana where rainfall is the lowest. Crop areas are the eastern and northern parts of Botswana.

The yield per hectare doesn't seem to follow the rainfall. This distortion may be due to labor shortages, the rainfall distribution, and other factors besides the total amount of rainfall.

RAINFALL(MM) AND TOTAL YIELD (100 METRIC TONNES)

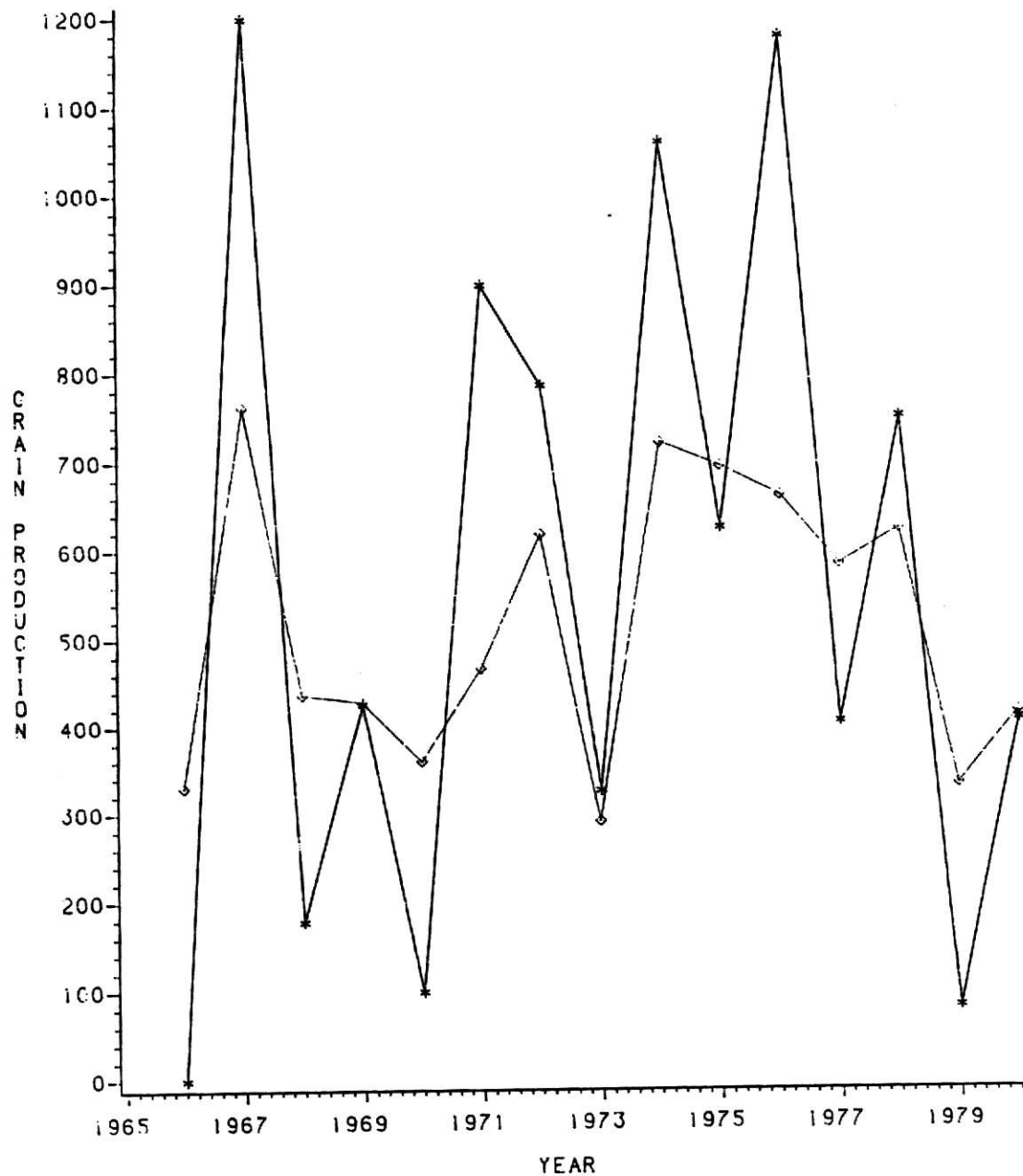


Figure 13.

* = Total yield
 ◇ = Rainfall

Table 9. Average Rainfall in Crop and Livestock Areas of Botswana.

	Units	Long Term Normal	Y E A R S														
			65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80
Weighted Average Rainfall for Crop Areas	mm	474	330	762	437	428	360	467	618	291	722	695	662	584	623	623	332
Weighted Average Rainfall for Cattle Areas	mm	451	314	708	404	394	330	419	583	254	718	657	643	549	616	616	325
% of Long Term Normal for Crop Areas	%	-	70	161	92	90	76	99	130	61	152	147	140	123	131	131	70
% of Long Term Normal for Cattle Areas	%	NA	70	157	90	87	73	93	129	56	159	146	143	122	137	137	72
Grain Production (Maize & Sorghum)	Metric Tons	-	-	120000*17800	42600	9900	89900	78600	32600	106100	62500	118100	45000*	75000	8000*	40700*	
Yields per Hectare	KG/ha	-	-	-	-	-	-	-	-	-	350	312.5	296	306	159	54	236
Area Planted (ha)	-	-	-	-	-	-	-	-	-	-	294	200	401	186	120	227.1	

* - Estimates

MULTIPLE REGRESSION MODELS AND RESULTS

Three regression models for the widely grown crops sorghum, maize, and beans were run to assess the factors that affect their productivity.

The yields per hectare of sorghum, maize, and beans were a function of rainfall, rainfall distribution, date of planting, area planted, and the number of livestock tended.

$$y_s = \gamma_0 + \gamma_1 R_{fi} + \gamma_2 Rd_i + \gamma_3 Pd_i + \gamma_4 Ap_i + \gamma_5 Lvstk_i + \epsilon_i$$

(sorghum yield per hectare)

$$Y_m = \beta_0 + \beta_1 R_{fi} + \beta_2 Rd_i + \beta_3 Pd_i + \beta_4 Ap_i + \beta_5 Lvstk_i + \epsilon_i$$

(maize yield per hectare)

$$Y_b = \alpha_0 + \alpha_1 R_{fi} + \alpha_2 Rd_i + \alpha_3 Pd_i + \alpha_4 Ap_i + \alpha_5 Lvstk_i + \epsilon_i$$

(bean yield per hectare)

where y_s = sorghum yield per hectare (KG/Ha)

y_m = maize yield per hectare (KG/Ha)

Y_b = bean yield per hectare (kg/Ha)

R_f = rainfall during the cropping season (for sorghum the period considered was from November to April but for maize and beans it was January to April only because these tend to be planted later in cropping season).

Rd = the rainfall distribtuion (A proxy, the standard deviation of the rainfall).

Pd = planting date (The number of days after the first day of recommended ploughing/planting (November 12th)).

Ap = area planted in hectares

Lvstk = the number of livestock kept measured in livestock units.

The above variables were collected for seven locations in Eastern Botswana, namely Makokwe, Polokwe, Gakgatla, Masunga, Matobo, Maunatlala, and Mookane for three years in 1978, 1980, and 1981. The 1979 data were not available since no farm management report was published for that year. The results were analyzied and shown below. Other models like using only two, three, or four independent variables were run through the computer but finally it seemed that all the variables should be reported. This is particularly important since the data was aggregated. Factors that may seem unimportant in the models may actually be important. Greater confidence of these results would be achieved if primary data for all the farms surveyed were treated individually not as averages for each location.

From the results in Table 10, it seems that planting date is one of the most important factors determining the yields per hectare of sorghum. One problem with the results is that the rainfall in the model is negatively related to the yields per hectare. This is hard to explain since rainfall in general enhances high yields. It may be possible that we have increased weed population in high rainfall years and if weeding is done late due to labor constraints then yields per hectare may be greatly reduced. Again these results are from aggregated data. To get

Table 10. Sorghum Regression Results With Sorghum Yields Per Hectare as Dependent Variable.

Independent Variables	Regression Coefficients	F-Value
R _{fi} (Rainfall)	-0.261273 (0.666015)	0.15 (NS)
R _d (Rainfall distribution)	-1.0829757 (3.13273)	0.12 (NS)
Pd (Planting date)	-2.704207 (2.906011)	0.87 (NS)
Ap (Area planted)	-3.990178 (29.239796)	0.02 (NS)
Lvstk (Livestock tended)	-0.65867 (2.206522)	0.09 (NS)

Ns = Not significant

F-values for individual regression coefficients

Model F = 1.56 (NS) R-square = 0.771761

a clearer picture we may need to look at the individual farm records. The results for sorghum may be influenced by intercropping of sorghum and other crops like melons, sweet reed, pumpkins, etc. Depending on the amount intercropped, this may distort the relationship between yields and rainfall. If many crops in addition to sorghum are intercropped then there may be competition among the crops and it may depress sorghum yields such that there is no direct relationship between rainfall and yield of sorghum. It is very useful to look at the primary data to verify if individual farm records did show this negative relationship between sorghum yields per hectare and rainfall. It might only be easily perceived in cases of excess rainfall not for sub-optimal rainfall places. Other coefficients are realistic, that it is quite plausible to expect the negative relationship between yields per hectare and the proxy for rainfall distribution.

Table 11 shows the yearly yield per hectare differences and Table 12 shows location of yields per hectare. There were no significant yearly yield per hectare differences, however, one location (Matobo) had significantly higher yields per hectare than any other location.

Results in Table 13 for maize were closer to the rationale that is in the literature than was sorghum. As expected the rainfall distribution seems to be the most important factor since maize is relatively more susceptible to soil moisture conditions. The area planted also seems important, this may indicate that high hectarages are not conducive to higher yields per hectare, mainly because of labor constraints that are usually very common. This impacts on the yield per hectare because weeding may be done later than the optimal time. Rainfall was also significant in

Table 11. Sorghum Yield Per Hectare by Year For The Years 1978, 1980, and 1981.

Year	Yield Means (KG/HA)	Standard Errors	LS Means (Year(I)) = LS Means (Year(J))
			1 2 3
1 1978	194.79	55.85	- NS NS
2 1980	277.31	36.95	- NS
3 1981	258.66	35.38	-

NS = Not significant at 5% level.

4 Table 12. Sorghum Yield Per Hectare by Location for the Period 1978, 1980, and 1981.

Location	Yield Means (KG/HA)	Standard Errors	LS Means (Location(I)) = LS Means (Location(J))
			1 2 3 4 5 6 7
1 Makokwe	191.78	51.44	- NS NS NS *
2 Polokwe	193.18	64.55	- NS NS *
3 Gakgatla	196.04	51.61	- NS NS *
4 Masunga	295.66	50.27	- NS NS *
5 Matobo	419.51	54.44	- *
6 Maunatlala	189.24	51.90	- NS
7 Mookane	219.70	47.97	-

* = Significant at 95% confidence level.

NS = Not significant at 95% level of significance.

Table 13. Maize Regression Results With Yields Per Hectare As
Dependent Variable.

Independent Variable	Regression Coefficient	F-Value
R _{fi} (Rainfall)	0.97401 (0.39571)	6.06*
R _{di} (Rainfall distribution)	-5.24223 (1.81243)	8.37*
P _{di} (Planting date)	-0.53367 (2.30210)	0.05
A _{pi} (Area planted)	-63.53375 (23.19543)	7.50*
Lvstk (Livestock)	2.44814 (1.64099)	2.23

Standard errors in parenthesis.

F-Values for individual regression coefficients.

* = Significant at 5% level.

yield per hectare determination. Through the examination of the results, we find that those locations with high standard deviation of rainfall tended to have extremely low yields. This is the case for Maunatlala. Even if the total rainfall is low, if its distribution is "good" (low standard deviation) yields tended to remain higher than when the distribution is "bad" (high standard deviation).

Table 14 shows the analysis of the maize yields per hectare by year. In general, the year 1981 had significantly higher yields per hectare of maize than the year 1980.

Table 15 shows Maunatlala which had low total rainfall and poor rainfall distribution to be the only location that was significantly low in its yields per hectare.

In Table 16 the results indicate that rainfall distribution is an important factor in bean production together with the total rainfall. Although the results are not significant, they are closely related to what can be expected. One possible anomaly with results is that usually beans are intercropped with sorghum, but it is interesting that the results seem not to follow the results from the sorghum data. Time of planting doesn't seem to be a critical factor for beans. Other variables of area planted and livestock tended do not seem very critical in the production of beans. This may indicate that labor constraints do not seem to have a great adverse effect on beans. This is because the variables of area planted and livestock tended could indicate the labor competition or pressure in crop production.

Area planted has a positive relationship with yield per hectare. It is not quite clear as to the possible relationship but it may be

Table 14. Maize Yield Per Hectare by Year For Years 1978, 1980, and 1981.

Year	Yield Means (KG/HA)	Standard Errors	LS Mean (Year(I)) = LS Mean (Year(J))		
			1	2	3
1 1978	174.09	36.71	-	NS	NS
2 1980	138.70	31.85		-	*
3 1981	268.39	30.40			-

* Significant at 5% level.

Table 15. Maize Yields Per Hectare By Location For Years 1978, 1980, and 1981.

Location	Yield Mean (KG/HA)	Standard Errors	LS Mean(Location(I)) = LS Mean (Location(J))						
			1	2	3	4	5	6	7
1 Makokwe	360.94	71.31	-	NS	NS	NS	NS	*	NS
2 Polokwe	83.98	60.98		-	NS	NS	NS	NS	NS
3 Gakgatla	178.36	51.05			-	NS	NS	*	NS
4 Masunga	129.02	59.89				-	NS	*	NS
5 Matobo	153.97	72.86					-	*	NS
6 Maunatlala	31.95	66.93						-	*
7 Mookane	481.79	121.54							-

* Significant at 5% level.

Table 16. Beans Regression Results With Bean Yields Per Hectare As the Dependent Variable.

Independent Variable	Regression Coefficient	F-Value
R _{fi} (Rainfall)	0.70560 (0.535968)	1.73 (NS)
R _{di} (Rainfall distribution)	-3.79377 (2.316489)	2.68 (NS)
P _{di} (Planting date)	-1.40998 (2.203726)	0.41 (NS)
Ap (Area planted)	2.3708 (29.867728)	0.01 (NS)
Lvstk (Livestock tended)	-0.938734 (5.593798)	0.03 (NS)

NS = Not significant

F-Values for individual regression coefficients

Model f = 0.68

R-Square = 0.594452

related to the fact that beans are usually intercropped with other crops such as sorghum or maize and usually beans are not considered the main crop. Again, the exact mix is usually determined by the individual farms.

Tables 17 and 18 show no significant differences in bean yields per hectare of either by year or by location.

Table 17. Bean Yields Per Hectare By Year For Years 1978, 1980, and 1981.

Year	Yield Mean (KG/Ha)	Standard Errors	LS Mean (Year(I)) = LS Mean (Year(J))		
			1	2	3
1 1978	71.58	56.64	-	NS	NS
2 1980	108.56	37.47		-	NS
3 1981	188.24	35.89			-

Table 18. Bean Yields Per Hectare By Location For Years 1978, 1980, and 1981.

Location	Yield Mean (KG/Ha)	Standard Errors	LS Means (Location(I)) = LS Means (Location(J))						
			1	2	3	4	5	6	7
1 Makokwe	108.68	52.15	-	NS	NS	NS	NS	NS	NS
2 Polokwe	8.9	65.44		-	NS	NS	NS	NS	NS
3 Gakgatla	176.54	52.34			-	NS	NS	NS	NS
4 Masunga	119.74	50.99				-	NS	NS	NS
5 Matobo	150.50	55.22					-	NS	NS
6 Maunatlala	161.77	52.63						-	NS
7 Mookane	133.40	48.64							-

DISCUSSION OF THE RESULTS

This study had both explanatory and confirmatory objectives. Explanatory, since it was to statistically test if the factors that are believed to affect production and productivity, do in fact seem to explain the variations. The study was also confirmatory for obvious factors, such as rainfall and rainfall distribution and to confirm the expected theoretical relationships among the regression coefficients, i.e., the signs of the regression coefficients.

Despite the fact that the period of analysis is too short and there were data problems, it seems that the data still explains and confirms the factors that do affect crop production and productivity in Botswana. These factors are specifically rainfall, rainfall distribution, and labor use per hectare. It also seems that maize production is not sensitive to planting date compared to sorghum particularly, and to a lesser extent, compared to beans. This confirms the recommendation of early planting by the Department of Agriculture Field Services but it may be added that this should be attached to sorghum. Late planting may be caused by late rainfall or unavailable draft power.

Labor constraints did not show as expected in the model, partly because averages of labor use per hectare per location would give little indication, since they are usually attached to the area ploughed/planted and cattle owned and the available labor per farm. These are usually unique for each farm, hence if data were available per farm it would be more explanatory than it is. There were other data problems as well.

MISSING OBSERVATIONS AND DATA PROBLEMS

The 1979 Farm Management Survey data was not analyzed and published and this was a great disadvantage in the analysis of the data, since there were no values for 1979 in many instances.

Another problem regarding the data is the aggregation of farmers and selection based on the dichotomy between crop and livestock farms, and then further classifying these farms into the top third, middle third, and bottom third in both categories regardless of whether these farms are tractor powered farms, cattle powered farms, donkey powered farms, and even without specification of male or female headed households. It is increasingly becoming clear that the analysis of traditional farming systems should always consider these categories as they provide "proxies" for income, management, and productivity. It is known for example, that tractor powered farms are generally more wealthy than cattle powered and donkey powered farms. Again, donkey powered farms are generally lower in terms of wealth to both cattle and tractor powered farms. There are other implications of the categories such as timeliness of ploughing and income for reinvestment in the agricultural operations. Therefore, we do not know who are the top crop or livestock farms exactly (donkey, cattle, or tractor powered farms), we just know some of their characteristics, such as high labor use per hectare, small hectarages, low cattle death rates, high cattle birth rates, low offtake, etc. It is not known whether there are donkey, tractor, or cattle powered farms. Another data information that was inadequate was the labor use of these categories of tractor, donkey, and cattle farmers. The breakdown of the data based on the type of power the farms used would give a clearer perception of the traditional farming system.

Hence, the data were analyzed as they were reported but it is very important to realize their limits, what there was, and what they do not imply. The data used were mainly averages for these farms in these locations for particular years and so the data have smoothed its "rough edges" as a result of aggregation.

With primary sources of data there would have been more flexibility to analyze individual farm records in each location rather than location averages and other data would have been included, such as labor use per hectare, which was collected but not fully reported.

Problems of secondary data have been mentioned in the study. It is not easy to account for the accuracy of this data since this study did not involve the collection of data from the farms but it was rather an extraction of compiled data for the farms and locations it was obtained from.

The sorghum data had several discrepancies that were hard to explain. Some locations with high total rainfall and relatively reasonable rainfall distribution had low yields. It has not been possible to explain the possible causes of this unusual relationship between the yields and the rainfall for sorghum.

It would have enhanced the accuracy of this study if labor use estimates were available for these locations. The regression analysis left a greatly important explanatory variable, the labor.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Many factors do seem to affect production and productivity in arable agriculture. In this study, the major factors that seem to determine the yield per hectare are the rainfall, rainfall distribution, labor use per hectare, and the availability of draft power. Rainfall and its distribution in general were the most significant variables in the model. Factors not analyzed in the model, like labor use per hectare have been shown to be strongly and positively correlated with yields per hectare, income per hectare, and man-days. From a basic comparison of data between farms with and without draft power, there are great differences in yields, and income. This is what would be expected from farms ploughing/planting in the later part of the cropping season and usually ploughing in sub-optimal conditions. Besides the extra "spinoffs" derived by farms with adequate draft power, such as milk incomes, it seems that direct benefits are timely ploughing/planting and ploughing desired hectarages, options that are not easily available to farms with inadequate draft power.

Other factors like the household head may not be important on their own, but probably when combined with inadequate draft power problems, then household head may be important. It is those factors that have great implications, either economic or agromomic, that tend to greatly affect the yields per hectare such as labor use and other resources owned, and the time of planting as

influenced by cattle or resource ownership.

The data seems to confirm consistently that sorghum ploughing/ planting is done first, followed by maize and beans. This would confirm the higher priority placed on sorghum. It is also observable from the data that particularly for maize, poor rainfall distribution (high standard deviation of rainfall) results in very low yields, because maize is high susceptible to moisture conditions.

Planting date does seem very important for sorghum production. In fact, most farms would not plough/plant sorghum after mid January, mainly because chances of good yields are very small. Planting date could be the third most important variable for beans, but with maize production, the planting date is very insignificant.

LIMITATION OF THE STUDY

Botswana's rainfall pattern fluctuates widely between years and seems to have a cyclical trend.¹ With these climatic conditions, the results from the study may, therefore, be unique for these years, particularly in the regression coefficients and in those factors associated with the climatic conditions, such as rainfall and its distribution.

There are other problems in the nature of the data used. The data is aggregated by locations. It has to be noted that these farms may be of different sizes and different resource endowments. Among the farms for example, there are tractor, cattle, or donkey powered farms. These farms may be different in their behaviour. Tractor

¹Oland, K., Alverson, H., Cummings, Jr., R. W., Targets for Agricultural Development in Botswana. page 15.

farms may not have labor problems, whereas the cattle and donkey powered farms have labor constraints. Such differences have not been accounted for in the data and in the analysis. We, therefore, may be aggregating technically different farms.

Another limitation regarding the data is that the period analyzed is short. Although in many cases year differences were not significant, three years is too short to have much confidence in the results. The results should be treated carefully and probably more in explaining the period studied.

Analyzing farms by location brings other problems, since there may be great variation between farms of the same location. For rainfall types found in Botswana, it is not uncommon to have farms in the same farming location with wide differences in total rainfall. The differences within locations have not been addressed in this study.

Therefore, a study on individual farm records would probably be more explanatory and farms would be analyzed further to assess the differences such as tractor farms, cattle, and donkey powered farms in their production.

This study is by no means a conclusive analysis of factors affecting yields per hectare in Botswana, primarily because of data limitations but it seems that some indicators do seem to confirm some literature about these factors. With primary data and more detailed data, perhaps a better picture of the effects of these factors affecting crop production in Botswana may be painted.

CHAPTER VI
APPENDIX

Appendix 1: Sorghum Data

Location	Year	Yield (KG/Ha)	Rainfall (MM)	Pl Date (Days)	Rain Dist (MM)	Area Pltd (Ha)	Lvstk (L.U.)
Makokwe	1978	124	385.3	41	27.6	11.30	32.0
	1980	277	258.7	29	40.2	7.20	33.0
	1981	276	468.7	36	79.9	6.05	38.3
Polokwe	1978						
	1980	274	304.2	31	46.6	4.20	29.0
	1981	164	559.4	68	85.3	4.91	33.3
Gakgatla	1978	104	536.0	47	82.0	5.60	31.0
	1980	272	256.1	59	35.2	4.40	28.0
	1981	354	252.4	46	52.4	5.50	30.0
Masunga	1978	132	606.4	49	90.7	4.60	29.0
	1980	456	428.1	52	71.7	4.20	30.0
	1981	162	524.5	56	100.0	3.83	32.7
Matobo	1978	190	751.8	38	108.6	3.30	20.0
	1980	517	346.6	28	54.7	3.70	79.0
	1981	338	599.8	56	112.4	3.56	23.2
Maunatlala	1978	230	354.3	22	32.9	3.70	79.0
	1980	125	484.2	36	101.9	2.00	93.0
	1981	294	319.9	15	67.1	3.46	94.9
Mookane	1978	207	388.0	52	57.3	10.20	65.0
	1980	279	494.8	41	82.6	10.60	78.0
	1981	196	377.5	60	47.4	10.92	93.2

Yield = Average yield per hectare in (KG/Ha).

Rainfall = Rainfall December to April in Millimeters.

Pl Date = Average days after the recommended planting date (in days).

Area Pltd = Area planted in Hectares.

Lvstk = Livestock Units tended in Livestock units.

Rain Dist = Rainfall distribution (standard deviation of the rainfall in millimeters).

Ka/Ha = Kilograms per hectare MM = Millimeters Ha = Hectares L.U. = Livestock units.

Appendix 2: Maize Data

Location	Year	Yield (KG/Ha)	Rainfall (MM)	Pl Date (Days)	Rain Dist (MM)	Area Pltd (Ha)	Lvstk (L.U.)
Makokwe	1978	175	291.8	29	27.6	11.60	32.0
	1980	169	184.9	23	40.2	7.20	33.0
	1981	460	411.7	37	79.9	6.05	38.3
Polokwe	1978	142	237.5	31	46.6	4.20	29.0
	1980	196	489.4	70	85.3	4.91	33.3
	1981						
Gakgatla	1978	139	375.3	53	82.0	5.60	31.0
	1980	144	189.4	28	35.2	4.40	28.0
	1981	264	152.8	40	52.4	3.83	30.0
Masunga	1978	230	414.2	47	90.7	3.30	29.0
	1980	225	351.0	59	71.7	3.70	30.0
	1981	154	477.5	58	100.0	3.56	32.7
Matobo	1978	214	555.1	40	108.6	3.70	20.0
	1980	273	317.1	29	54.7	2.00	21.0
	1981	348	529.7	56	112.4	3.46	23.2
Maunatlala	1978	188	377.8	35	32.9	3.70	79.0
	1980	0	599.7	45	101.9	2.00	93.0
	1981	38	440.6	35	67.1	3.46	94.9
Mookane	1978	102	218.5	49	57.3	10.20	65.0
	1980	176	413.3	21	82.6	10.60	78.0
	1981	367	252.0	48	47.4	10.90	93.2

Yield = Average yield per hectare in (KG/Ha).

Pl Date = Average days after the recommended planting date in days.

Area Pltd = Average area planted in Hectares.

Lvstk = Average livestock units tended.

Rain Dist = Standard deviation of the rainfall in millimeters.

KG/Ha = Kilograms per hectare

MM = millimeters

Ha = Hectares

L.U. = Livestock units.

Appendix 3: Beans Data

Location	Year	Yield (KG/Ha)	Rainfall (MM)	P1 Date (Days)	Rain Dist (MM)	Area Pltd (Ha)	Lvstk (L.U.)
Makokwe	1978	171	291.8	28	27.6	11.30	32.0
	1980	173	184.9	13	40.2	7.20	33.0
	1981	98	411.7	40	79.9	6.05	38.3
Polokwe	1978						
	1980	24	237.5	34	46.6	4.20	29.0
	1981	64	489.4	67	85.3	4.91	33.3
Gakgatla	1978	167	375.3	51	82.0	5.60	31.0
	1980	81	189.4	61	35.2	4.40	28.0
	1981	270	152.8	42	52.4	3.83	30.0
Masunga	1978	23	414.2	54	90.7	3.30	29.0
	1980	112	351.0	44	71.7	3.70	30.0
	1981	157	477.5	56	100.0	3.56	32.7
Matobo	1978	127	555.1	31	108.3	3.70	20.0
	1980	94	317.1	30	54.7	2.00	21.0
	1981	196	529.7	56	112.4	3.46	23.2
Maunatlala	1978	307	313.3	35	32.9	3.70	79.0
	1980	40	415.7	38	101.9	2.00	93.0
	1981	68	241.4	13	67.1	3.46	94.9
Mookane	1978	53	218.5	52	57.3	10.20	65.0
	1980	144	413.3	22	82.6	10.60	78.0
	1981	252	252.0	63	47.4	10.90	93.2

P1 Date = Average days after the first recommended planting date (October 12th).

Rain Dist = Standard deviation of the rainfall (Proxy for rainfall distribution).

Area Pltd = Average area planted in hectares.

Lvstk = Average livestock tended.

Yield = Average yield per hectare in kilograms per hectare.

KG/Ha = Kilograms per hectare MM = millimeters Ha = Hectares L.U. = Livestock units.

CHAPTER VII
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ANALYSIS OF FACTORS AFFECTING TRADITIONAL
AGRICULTURE IN EASTERN BOTSWANA

by

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ABSTRACT

The improvement of traditional agriculture has been one of the main goals for development in Botswana. To attain that goal a knowledge of the factors affecting agricultural production will be useful. The objective of this research was to increase the understanding of factors affecting agricultural production.

The study was conducted using mainly the Farm Management Survey data for years 1978, 1980, and 1981 collected in nine locations. The study was designed to analyze descriptively and statistically the factors affecting agricultural production and to compare these findings to findings from other studies. Factors affecting agricultural production may be classified into climatic factors such as rainfall, rainfall distribution, temperatures, planting date (if late planting results from late rains); economic and economic related factors like domestic and South African off-farm employment, income, number of cattle owned (cattle ownership can be used as a proxy for wealth or income), planting date (if late planting is a result of lack of incomes to hire draft power or lack of draft power); agronomic factors like weeding, planting date; and household factors such as available family labor, hired labor.

The results of this analysis indicates that rainfall and rainfall distribution are the primary factors affecting crop yields per hectare. Planting date is an important factor determining yields, particularly for sorghum and beans. Planting date was not an important factor affecting the yield of maize. Rainfall distribution was important for maize and bean yields but not for sorghum yields. Although the regression models showed that labor proxies were not significant, the same data when

analyzed for top, middle, and bottom third crop farms show that labor use per hectare influences yield. The results also indicate that though livestock production (cattle) enhances crop production (by draft power, timely ploughing/planting and incomes) labor and other resources may be inadequate for both livestock and crop production. Some farms may be allocating inadequate resources to their crop and/or livestock enterprises (labor, management, etc.). This is shown by the tradeoff between livestock and cropping enterprises in traditional farms.

The limitations of this study are the short time period of the data, the small number of observations, and the aggregation of the data used in the analysis. These limitations constrained the results of the analysis.