ARABLE FARMING DEVELOPMENT PRIORITIES
IN THE CENTRAL AGRICULTURAL REGION, BOTSWANA:
A FARMING SYSTEMS ANALYSIS

By

Doyle Curtis Baker

A DISSERTATION

Submitted to
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in partial fulfillment of the requirements
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DOCTOR OF PHILOSOPHY

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1987

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ABSTRACT

ARABLE FARMING DEVELOPMENT PRIORITIES
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There is an urgent need to identify ways to develop arable farming in Botswana in order to reduce national dependence on food imports, save foreign exchange, create rural employment, raise rural incomes, and reduce household dependence on government subsidies.

The goal of this thesis is to provide a comprehensive, systems analysis of arable farming in the Central Region, and the factors affecting arable farming, in order to determine arable farming development priorities. The analysis is based on village and on-farm surveys and experiments carried out between October 1982 and June 1986.

The thesis uses the farming systems approach. The farming systems approach: (a) is holistic not reductionist, (b) generally uses households, farm systems or production subsystems as the unit of analysis, and (c) follows a systems problem evaluation sequence. The systems approach used in the thesis encompasses household circumstances, traditional crop systems management, and local institutions, as well as experimentation to identify improved practices.

The analysis of household circumstances describes the resource constraints affecting arable farming development and reveals a more pervasive pattern of inequality than is indicated in previous studies. Recommendations are given on technical research priorities and targeting strategies.

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The analysis of crop systems management focuses on farmers' perceptions and priorities, and the diversity in traditional practices. Several potentially valuable technical investigations are identified.

An overview is given of the on-farm experiments carried out between 1982 and 1986. The trials program primarily focused on modifications in the traditional broadcast, single plow system. A series of budget analyses based on the on-farm trials shows there are modified practices which can be profitably adopted even during drought conditions.

The analysis of agricultural support systems covers the extension service, local traders, village groups, and two agricultural assistance programs. Guidelines are given on appropriate institutional changes.

In the final chapter, a comprehensive strategy for arable farming development is proposed and an assessment is given of the holistic research approach used in the thesis.

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ACKNOWLEDGMENTS

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I would particularly like to acknowledge my debt to Dr. Jay Siebert, my Central Region team collegue. Dr. Siebert designed and analyzed most of the on-farm trials carried out by the team. More importanly, many of my ideas about arable farming development resulted from endless hours of discussion with Dr. Siebert.

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The research was possible only because of the efforts of my Batswana counterparts, including at different times: Meschack Tjirongo, Chada Tibone, John Lesotlho and Catherine Jonas. This thesis represents their product as much as it does mine.

In addition to the above, many other ATIP staff contributed to the research. E. Modiakgotla and J. Luzani, both team agronomists, provided assistance when needed. The following field staff collected data and helped implement trials: D. Dira, C. Mahilo, K. Okaile, R. Mosojane, R. Serumola, and G. Mogotsi. Administrative assistance and data entry were provided by K. Seleke, L. Seretse, and P. Monyane.

Perhaps my greatest debt is to the many farmers who participated in the research. During four difficult seasons, they answered questions and tried new practices withh little personal benefit.

At Michigan State, guidance committee members Eric Crawford, Carl Eicher, Glenn Johnson and Carl Liedholm provided advice and criticism which led to major improvements in the thesis. Rick Bernsten participated on the dissertation committee and gave constructive comments on the thesis organization. Special acknowledgments are due Drs. Crawford, Eicher and Johnson.

Dr. Crawford assumed the responsibility of being major professor and thesis supervisor when he could not afford the time. He worked with me to make the thesis more focused, without losing its systems orientation. I greatly appreciate his helpful comments.

Dr. Eicher was my major professor and mentor throughout my graduate program at Michigan State. He took a personal interest in my career development and provided me with innumerable opportunities to learn and grow.

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Dr. Johnson is responsible for the intellectual perspective of the thesis (though not accountable for its weaknesses).

I also would like to thank Drs. Connor and Mandersheid for the support provided by the Department of Agricultural Economics, both while I was a graduate student and in the years since when I have periodically returned to campus to finish the thesis.

Finally, I would like to thank my parents and wife, Kathy, for the patience they have shown. Seven years is a long time to wait. I am sure they wondered if the waiting would ever end.

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AC, Agricultural I

ALDEP, Arable Lan

APRU, Animal Prod

AAP, Accelerate

ARS, Agricultural

ATIP, Agricultura

BAMB, Botswana Ag

BMC, Botswana Mea

CIMMYT, Internati

CSO, Central Stat

DAFS, Department

DAO, District Agr

DAR, Department o

DP, Double Plow

DPS, Division of

DLFRS, Dryland Fa

DMU, Decision Un

EFSAIP, Evaluatio

ESM, Economic Sur

FAO, Food and Agr

FM, Farmer Manage

FI, Farmer Implem

FSR, Farming Syst

GOB, Government o

IPPP, Integrated

LBDR, Labor-Base

MOA, Ministry of

MFDP, Ministry o

MVTC, Multiple-V

NDP, National De

NFMS, National F

NMS, National Mi

PSC, Planning an

RDC, Rural Devel

RIDS, Rural Inco

RI, Researcher I

RM, Researcher M

RSC, Rural Socio

SP, Single Plow

USAID, United St

VDC, Village Dev

LIST OF ABBREVIATIONS

AD, Agricultural Demonstrator
ALDEP, Arable Lands Development Program
APRU, Animal Production Research Unit
ARAP, Accelerated Rainfed Arable Program
ARS, Agricultural Research Station
ATIP, Agricultural Technology Improvement Project
BAMB, Botswana Agricultural Marketing Board
BMC, Botswana Meat Commission
CIMMYT, International Maize and Wheat Improvement Center
CSO, Central Statistics Office
DAFS, Department of Agricultural Field Services
DAO, District Agriculture Officer
DAR, Department of Agricultural Research
DP, Double Plow
DPS, Division of Planning and Statistics
DLFRS, Dryland Farming Research Scheme
DUMI, Decision Unit Management Information
EFSAIP, Evaluation of Farming Systems and Implements Project
ESM, Economic Survey Mission
FAO, Food and Agriculture Organization
FM, Farmer Managed
FI, Farmer Implemented
FSR, Farming Systems Research
GOB, Government of Botswana
IFPP, Integrated Farming Pilot Project
LBDR, Labor-Based Drought Relief
MOA, Ministry of Agriculture
MFDP, Ministry of Finance and Development Planning
MVRU, Multiple-Visit Resource Use
NDP, National Development Plan
NFMS, National Farm Management Survey
NMS, National Migration Study
PSU, Planning and Statisics Unit
RDC, Rural Development Council
RIDS, Rural Income Distribution Study
RI, Researcher Implemented
RM, Researcher Managed
RSU, Rural Sociology Unit
SP, Single Plow
USAID, United States Agency for International Development
VDC, Village Development Committee

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I. INTRODUCTION

This research provides information on farming systems in the Central Agricultural Region, Botswana. The Central Region is the largest agricultural region in Botswana and encompasses more than a quarter of its farmers (Figure 1.1). The level of crop production in the region is low and unstable, as it is throughout Botswana. Even in years with good rainfall, many farmers do not produce enough to feed themselves. In drought seasons, nearly all farmers rely on government production subsidies and feeding programs, and on purchased food.

The research covers household circumstances, crop systems management, experimentation on production practices, and agricultural support systems. The research is based on village and on-farm research carried out between October 1982 and June 1986.

This chapter gives background information on national development and the role of agriculture, presents a problem statement, summarizes the research objectives, and describes the organization of the thesis.

A. BACKGROUND

Botswana is a lightly populated, land-locked country in southern Africa, just north of South Africa. Two-thirds of its 582,000 square kilometers are covered by the desert and semi-desert sands of the Kalahari. Most of the population of around one million people is concentrated in villages located on the eastern border of the country.

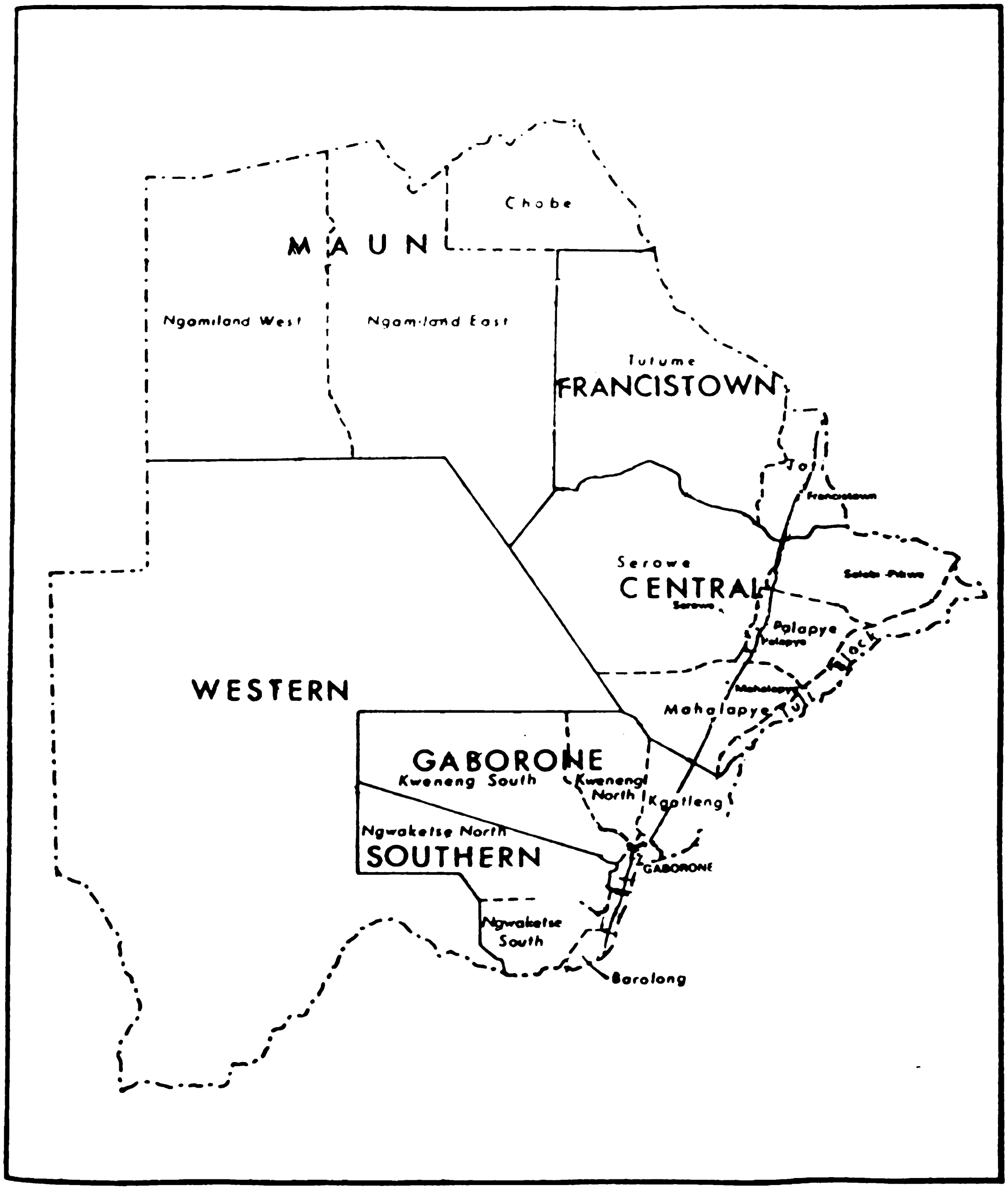

FIGURE 1.1: MAP OF BOTSWANA; AGRICULTURAL REGIONS AND DISTRICTS

1. PROFILE OF NA

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1. PROFILE OF NATIONAL DEVELOPMENT

When Botswana became independent in 1966, it was one of the poorest countries in Africa and was in a life threatening drought. There had been little institutional, infrastructural or industrial development. Livestock and remittances from mine laborers working in South Africa were the major sources of rural household and national income.

During the 1970s, circumstances in Botswana changed dramatically. Four events had a significant impact on national development. First, the country was found to possess mineral wealth on a large scale. There is copper, nickel, coal, iron ore, manganese and two massive diamond mines. Diamonds alone account for two-thirds of the value of exports [MFDP, 1985]. Second, the Lome Agreement with the EEC provided Botswana with access to the European beef market at no or reduced tariffs. Third, the Southern African Customs Union Agreement was renegotiated to allocate Botswana a larger share of customs union revenues. Fourth, the drought of the 1960s was followed by several years of good rainfall, allowing a tremendous expansion of the national cattle herd.

The combined effect of these events was a dramatic restructuring of the Botswana economy. First, there was a large increase in earnings (including rural earnings). Between 1966 and 1983, the gross domestic product grew at an average annual rate of 13 percent [MFDP, 1985]. Second, there was a rapid expansion of demand, particularly demand for imports [Dahl, 1981]. Imports rose by around 400 percent during the decade following independence. Third, based on mine rents and customs union revenues, a budgetary surplus was achieved in 1983, and has been maintained since [Lewis, 1981]. Fourth, the contribution of agriculture

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to GDP fell from 39 percent in 1966 to 7.4 percent in 1983. By 1983, the contribution of agriculture was outstripped by mining, manufacturing, trade and hotels, services and government.

Accompanying the change in the economic picture, major strides were made in rural infrastructure, particularly with respect to roads and borehole development, and rural services such as primary education and clinics. Meanwhile the political climate remained conducive to development. As a result, by the end of the 1970s, Botswana was being viewed as one of the outstanding success stories in Africa.

Despite its notable successes, the GOB has not been able to eliminate three persistent development problems: (a) vulnerability of the economy to shifts in export demand, (b) insufficient employment generation, and (c) poor and erratic performance of the crop farming sector [MFDP, 1985].

The vulnerability of the economy was made clear during the late 1970s when Botswana beef was temporarily banned from the EEC due to an outbreak of Food and Mouth Disease. Before the economy had fully recovered, the export demand for diamonds dropped. The net effect was rapid swings in the balance of payment between 1978 and 1983.

The employment problem resulted largely from the pattern of diamond dependent development [Lewis, 1981]. Because there are few linkages from diamond mining to the rest of the economy, the expansion of formal sector employment was much less than the rate of growth of value added [Dahl, 1981]. Moreover, the increase in employment opportunities was largely offset by an increasing number of job seekers. The lack of formal sector job opportunities led to a problem of rural underemployment, with nearly half the potential labor time not being used [Lipton, 19

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2. ROLE OF AGRICULTURE

By the mid-1970s, agriculture was no longer the largest economic sector but it has continued to play a vital role in national development. Over eighty percent of rural households and a large share of urban households are involved in agricultural production. A viable agricultural sector is necessary to reduce national dependence on food imports, save foreign exchange, create rural employment opportunities and raise rural incomes.

The Government of Botswana recognizes the importance of agriculture. Cattle historically have been the backbone of the rural economy and development of a strong commercial livestock sector was a priority during the first four national plans. The commercial livestock sector remained the top priority in the 1979-85 National Development Plan (NDP V) but, motivated by a concern with equity and employment opportunities, the Ministry of Agriculture was mandated to increase the emphasis given to crop production, limited resource farmers and communal area livestock development. Continued emphasis on commercial livestock production would have had severe equity implications since many households do not have cattle [CSO, 1976].

Although the Ministry of Agriculture received an increased budget allocation under the 1979-85 NDP, financial and trained personnel resources available to the Ministry of Agriculture continued to be limited [Litschauer, 1980]. Through 1981, there had been little progress toward the goals envisioned for agricultural policy.

The performance of the arable farming sector became a critical national problem when, in 1981, another drought started. Between the

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1977-78 season and the 1982-83 season, the agricultural GDP fell 33.6 percent. Food grain production fell to 10,000 tons, less that ten percent of national food grain requirements. There was a 20-30 percent drop in the number of households planting crops. As a result, estimated employment in crop production dropped from around 250,000 in the mid-1970s to 190,000 in the early 1980s [RDC, 1985].

To stimulate farm employment, maintain rural assets and ensure household food security, the government has set up several feeding and agricultural assistance programs which subsidize rural households. In 1984, more than a third of the total population received supplementary rations equivalent to 35 percent of their basic food needs [RDC, 1985]. Food provided through the various feeding programs accounted for nearly 25 percent of the total availability of staple grains. At the same time, all farmers were eligible to receive 20 kilograms of free seed, an 85 percent subsidy on plowing (up to three hectares), payments for field destumping, subsidized stockfeed, and free or subsidized livestock vaccinations. In addition, farmers having fewer than forty cattle could receive an 85 percent subsidy for the purchase of implements, fencing, and water catchment tanks, and a 60 percent subsidy for traction animals.

The government does not want to continue the various feeding and agricultural assistance programs at their current level [MFDP, 1985; RDC, 1985]. In addition to the political drawbacks from national dependence on food imports and household dependence on the government, the programs simply are not sustainable. The current National Development Plan (NDP VI) projects that the growth of mine revenues will begin falling in the next few years while the growth of government expenditures wil

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expenditures will increase, leading to a government budget deficit. Therefore, the government expects to have a declining ability to pay for food imports and provide free or subsidized food and agricultural inputs to rural households. Consequently, the Ministry of Agriculture must develop a viable strategy for addressing the stagnation and erratic performance of arable agriculture.

B. PROBLEM STATEMENT

The problem addressed in this thesis is the limited capacity of the Ministry of Agriculture to identify ways to contribute to arable farming development which are not based on resource transfers and subsidies. At present, Ministry officials do not know enough about farmers' resources, managerial practices and decision processes to evaluate and target improved crop production technologies and support systems.

Because of the Ministry's limited capacity to develop programs for different target groups, the agricultural assistance programs encompass large segments of the population and the same extension recommendations are made to all farmers. The result is that richer households benefit as much or more from the assistance programs as do poorer households [Holm and Cohen, 1986] and few households follow the main extension recommendations.

To contribute to arable farming development, the Ministry needs more information about several issues, including the following: (a) How do resources (human, land, capital, and livestock) affect the relevance of different technologies and programs; (b) Do rural households have the time and cash to invest in new practices or implements; (c) Can traditional practices be modified to increase production; (d) What do farmers think about the practices recommended by the Ministry; (e) Are there any produc

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there any production practices which perform well under drought conditions; and (f) Are there institutional constraints which might be addressed to facilitate crop development?

The lack of information on the above issues is not due to an absence of agricultural and rural development research in Botswana. Instead, lack of information can be attributed to: (a) the pattern of past agricultural research and (b) the change in national circumstances since the 1970s.

Several anthropological studies have provided information on household dynamics and village institutions, such as Schapera [1943], Kerven [1977], Alverson [1978] and Gulbrandsen [1980]. Although valuable, these studies generally have not addressed production practices or agricultural support systems, nor have they identified options for the Ministry of Agriculture.

Much of the information about Botswana agriculture has been generated through national studies with predetermined mandates to focus on a particular issue. During the 1970s, there were at least four major studies, one focused on the (now ended) food-for-work program [FAO, 1974], one on income distribution [CSO, 1976], another on employment [Lipton, 1978], and the fourth on migration [CSO, 1982]. These studies provided information on agricultural households and the rural economy. They were invaluable in describing the circumstances of poor rural households, particularly households without cattle and female-headed households.

The importance of the various national studies is reflected in the influence they have had on national planning. The studies were unanimous in urging the government to shift its orientation toward the

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poor. Most recommended a focus on crop production and rural employment generation. A common prescription was to create access to productive capital, both livestock and implements, in order to increase the returns in agricultural production. The main recommendations and prescriptions of the studies were accepted in NDP VI. ALDEP was set up to provide productive capital. Within a few years, however, ALDEP was changed into another subsidy program.

The Ministry of Agriculture now knows it should focus on the poor and it knows, in general, who the poor are. It does not, however, know what to do about the poor or about the stagnation of crop production in general. The various national studies say little about production practices, relationships between household circumstances and technology development, or agricultural support systems.

A third source of information, which does address production practices, is the agricultural research which has been carried out by the Ministry. Unfortunately, agricultural research by the Ministry generally has been equated with technical research and, until the mid-1970s, most technical research was carried out on experiment stations. Few guidelines were developed for farmers because of: (a) a large gap between management of the on-station trials and farmers' practices, (b) a lack of significant yield benefits from many tested practices, and (c) a failure to evaluate the economic benefits from alternative practices (for examples, see ARS [1978] and DAR [1969]).

The weakness of on-station technical research was recognized in the 1970s and two multidisciplinary on-farm research projects were initiated. These projects, however, concentrated on testing technological packages generated through on-station research [Gaosegelwe

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et al., 1983]. After more than five years of limited success, both projects turned to a farming systems approach but, even then, one project focused mainly on improved implements and the other focused on livestock interventions [Baker and Hobbs, 1986]. Neither project dealt with farm systems in the Central Region and neither addressed issues such as patterns in household resources, whole farm labor use, cashflows, food consumption, variations in traditional practices, or the functioning of local institutions, and how these issues influence arable farming development.

Finally, the Ministry does generate its own information for planning through national farm management and agricultural statistical surveys carried out each year by the Division of Planning and Statistics. Both surveys, however, concentrate on a limited range of data required for characterizing production trends and the returns to resources. The data ignore mixed cropping, patterns in traditional practices, wage employment, income sources, household labor allocation, gender roles, resource sharing, and market participation (see Boykin [1983] and CSO [1984]).

As a result, little is known about the relationships between household circumstances, crops systems management, modified production practices and local agricultural institutions in the Central Region. Therefore, an integrated, farming systems analysis is needed in order to provide guidance to Ministry of Agriculture personnel and to improve their capacity to contribute to arable farming development.

C. RESEARCH OBJECTIVES

The goal of this thesis is to provide a comprehensive, systems analysis of arable farming in the Central Region, and the factors affecting a

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affecting arable farming, in order to determine arable farming development priorities. To accomplish this goal, the specific research objectives are as follows:

1. To describe patterns in household resource control and use, and to identify the implications of household circumstances for arable farming development.
2. To generate information on existing production practices, and farmers' priorities and perceptions, in order to identify technology development priorities.
3. To characterize cropping outcomes, and to identify production practices which can improve cropping outcomes even under drought conditions.
4. To analyze the performance of agricultural support systems, and to identify policy and institutional options to improve their performance.

D. ORGANIZATION OF THESIS

Chapter II describes the research approach. The conceptual framework is introduced. After that, an overview is given of the field research activities and the data analysis procedures. The final section identifies the distinctive features of the research approach.

Chapter III gives an overview of the household circumstances affecting arable farming. Information is presented on human, land, labor, capital and livestock resources. Household resources are key parameters affecting farm system performance and options for improved performance. Household labor use, revenue and expenditure, and food consumption patterns are also described in order to place arable crops production into a household and farm systems context. At the end of the chapter

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chapter, the main implications of a household and farm systems perspective for arable farming development are highlighted.

Chapter IV shifts from a household perspective to an analysis of crop systems management. Information is presented on cropping objectives, crops and varieties, draft management, traction use patterns, production practices, post-harvesting practices, and roles in decision-making. Attention is given to farmers' priorities and perceptions, as well as to describing current practices. The final section identifies implications of crops systems management for arable farming development.

Chapter V gives an assessment of cropping outcomes and reviews the efforts which have been made to identify improved arable production technologies. The results of the on-farm trials are described and budget analyses are presented for the most promising practices. The budget analyses focus on minor changes since the harsh and uncertain environment precludes as too risky interventions which require substantially increased investments.

Chapter VI presents information on the performance of three agricultural support systems. The first section gives an evaluation of agricultural extension in the Central Region. The trading network in the Central Region is addressed in the second section. The third section examines village groups and a group formation "institutional experiment." The final section gives recommendations on policy and institutional changes.

The last chapter reviews the research approach and objectives, summarizes the findings, points out implications for the Ministry of Agriculture, identifies limitations of the research, and suggests priori

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priorities future on-farm research in Botswana.

The Appendix gives an overview of agriculture in Botswana, for readers not familiar with Botswana. Information is given about the technical environment, the agricultural sector structure, recent production trends, production practices in the different agricultural regions, and the main agricultural institutions.

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II. RESEARCH APPROACH

The thesis is based on village and on-farm research carried out under the auspices of the Agricultural Technology Improvement Project (ATIP). This chapter gives an overview of the research approach. The first section introduces the ATIP project. The next three sections describe: (a) the conceptual framework which guided the research, (b) the field research activities, and (c) data analysis procedures. The final section points out four distinctive features of the research approach.

A. AGRICULTURAL TECHNOLOGY IMPROVEMENT PROJECT

ATIP was initiated in 1982 with a mandate to improve the capacity of the Ministry of Agriculture to develop and extend technologies relevant to the needs of resource poor farmers. To accomplish the mandate, there were four main components to the project: (a) an agricultural economist was based at the main research station in order to strengthen the capacity for multi-disciplinary research, (b) an agronomist was appointed to a newly created position of Research-Extension Liaison Officer (RELO), (c) long- and short-term training were provided to Ministry officers, and (d) two on-farm research teams were established. The core of the project was the two on-farm research teams. One had a mandate to cover the Central Agricultural Region. The second had a mandate to cover Tutume District in the Francistown Agricultural Region.

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The Central Region team comprised two expatriates--an agronomist and an agricultural economist--plus counterparts and field assistants from the Ministry of Agriculture. The team had a mandate to focus on crop production and the crop-livestock interface. The objective was to improve arable farming in a manner that contributed to equity and national food independence. The target group of farmers was defined to be those cultivating from one to ten hectares and having fewer than forty head of cattle.

B. CONCEPTUAL FRAMEWORK

Arable farming development priorities in the Central Region were analyzed using a farming systems approach. The farming systems approach has three distinguishing characteristics: (a) reductionism is rejected in favor of a systems perspective, (b) farm systems generally are taken as the unit of analysis, and (c) a systems problem evaluation process is followed.

This section defines the term "system," characterizes the systems perspective, introduces the concept of a farm system, and describes the problem evaluation sequence. The systems problem evaluation procedures used in this research are comparable to those developed by CIMMYT for "on-farm research with a farming systems perspective" [Byerlee, Collinson, et al., 1981] and by Norman for the "farming systems approach to research" [Gilbert, Norman, Winch, 1980] but are presented using terminology suggested by Manetsch and Park [1979].

1. DEFINITION OF A "SYSTEM"

A system is a set of interacting components which are organized toward a goal or set of goals. A system reacts as a whole to external

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stimuli and each system has a specified boundary based on the inclusion of all significant feedback [Spedding, 1979; Dent and Anderson, 1971].

Following Manetsch and Park [1979], systems can be identified with reference to input variables, output variables, and parameters which define the system structure. The system structure is the set of interacting components (or subsystems) and related variables (including parameters) that link system outputs to system inputs. System parameters are the fixed attributes of the system structure. System input variables include environmental and controllable inputs. Environmental inputs affect the system but are not significantly influenced by it and, therefore, are beyond the boundary of the system. Controllable inputs are provided by system managers. System outputs can be either desired or undesired. System performance refers to the success of a system in attaining desired outputs.

2. SYSTEMS PERSPECTIVE

The systems perspective is the antithesis of reductionism. Following Dillon [1976], the reductionist approach entails reducing phenomena to more basic parts, analyzing the parts as independent entities, and then aggregating the results in order to explain the phenomena under study. Dillon argued that reductionism has led disciplinary researchers away from real world problems. Dillon contrasted reductionism with the systems concepts of expansionism and teleology. Expansionism is the view that all objects and events are parts of larger wholes. Teleology is the belief that purpose and design affect phenomena. The teleological approach involves setting a target and assessing alternative actions for achieving the target.

The practical limitations of reductionism have been identified by

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many systems analysts. Two arguments are frequently mentioned. One relates to global versus local optimization. It is argued that optimization with respect to a part of a system does not necessarily mean that the performance of the entire system will be improved. The second holds that the whole of a system is greater than the sum of the parts. Because of the synergistic interactions of systems components, systems cannot be studied by considering their components in isolation [Rountree, 1977].

Dillon [1976] said that the systems approach inherently leads to better understanding since it is more consistent with real world processes. With reference to specific contributions, Dillon argued that the systems approach: (a) provides an indication of where research is needed, (b) helps researchers to consider more than the material product of agriculture, and (c) provides a workable procedure for research, and for evaluating the likely ramifications of research.

Based on the expansionist and teleological concepts, the search for solutions using the systems perspective cuts across the boundaries of traditional disciplines and is philosophically eclectic, with an emphasis on pragmatism. A distinguishing feature of pragmatism is the belief that knowledge is valid only if it leads to "workable solutions" to identified problems [Johnson, 1986].

3. FARM SYSTEMS CONCEPT

A farm system is a biological, social and physical system in which decision makers attempt to control biological subsystems in an uncertain environment in order to achieve multiple goals. "Farming systems" are groups of farm systems which have nearly the same social, institutional and technical environment and, as a result, pursue similar goals through

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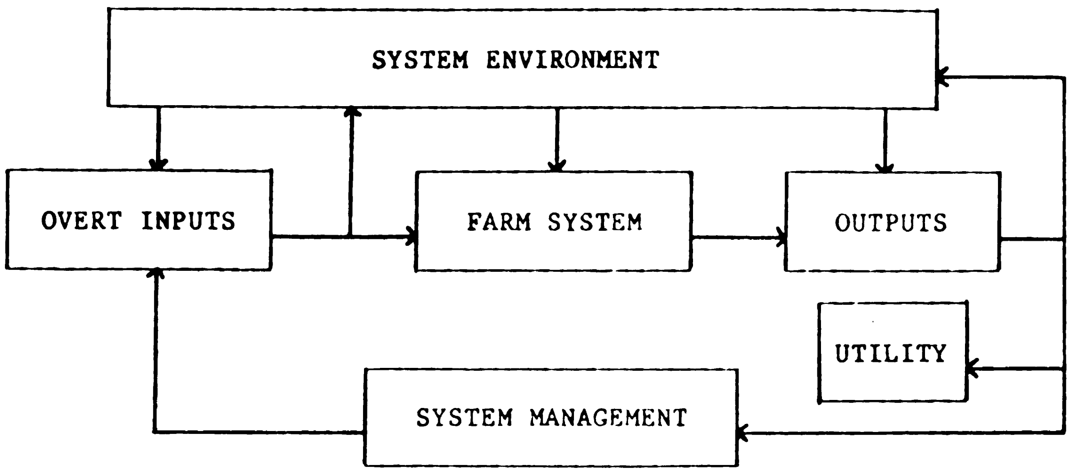
similar sets of system components. In a strict sense, farming systems generally are not systems since: (a) no boundary is specified which includes all significant feedback and (b) they do not react as a whole to external stimuli.

A farm system encompasses most, but not all, the activities of an agricultural household. Agricultural household activities also include wage employment, schooling, child rearing, gathering, and attending ceremonies. Consequently, research on farm systems may be sufficient for addressing most of the factors affecting households, but not all.

A farm system can be viewed as having a management unit which is responsible for the standard management functions, including problem identification, observation, analysis, decision making, taking action and assuming responsibility for outcomes. The goals of the management unit are accomplished by adjustments in the timing, level and composition of controllable inputs applied to the various subsystems. The management unit usually does not consist of a single individual.

Farm system managers have limited control over the nature and output of the system. The structure and performance of a farm system are determined primarily by the system environment and by endogenous, but uncontrollable in the short run, system parameters. Farm system parameters include the number and composition of components (or subsystems), demographic composition of a household, behavioral characteristics of system managers and household assets.

A model farm system model is given in Figure 2.1. The first part of the figure shows a general model which characterizes all farm systems. The second part lists the key inputs, outputs, system components, and resource parameters identified for farm systems in the



IDENTIFICATION OF BOTSWANA FARM SYSTEMS

SYSTEM ENVIRONMENT:
- **Technical:** Soils, Rainfall, Climate, Topography
- **Biological:** Birds, Livestock, Pests and Vegetation; Varieties
- **Rural Economy:** Prices, Wages, Credit, Input & Output Markets
- **Village Institutions:** Groups, Inter-Household Exchanges
- **Government Programs:** Drought Relief, ALDEP, Extension, ARAP

INPUTS: Labor, Cash, Traction, Seed, Implements, Land

FARM SYSTEM:
- **Components:** Crop Production, Livestock Husbandry, Beer Brewing
- **Demographic:** Size, Residence, Sex of Head, Education
- **Assets:** Livestock, Land, Implements, Buildings
- **Behavior:** Perceptions, Priorities, Beliefs

OUTPUTS: Food, Beer, Consumer Goods, Livestock, Cash

FIGURE 2.1: A FARM SYSTEM MODEL

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Central Region. Structural relations between system components are implicit in the feedback loop (through management) in which outputs from one component can contribute directly to utility or can have instrumental value.

4. SYSTEMS PROBLEM EVALUATION SEQUENCE

The farm systems model does not indicate what should be investigated, or how an investigation should proceed. To investigate farm systems in the Central Region, a systems problem evaluation sequence was used.

There are many characterizations of the systems problem evaluation sequence in the farming systems literature. The most common representation was developed by D. Norman [1980]. Norman proposed four stages of research: description and diagnosis, design, testing and extension. Norman's terminology identifies processes which are conceptually distinct, although they may be carried out at the same time or even in a different order than is implied in use of the term "stages."

A problem with most representations of the systems problem evaluation sequence is that they assume a focus on technology evaluation. In this research, however, information is another important output. Information can relate to human and institutional perspectives as well as to technologies. Therefore, a slightly different conceptualization of the systems problem evaluation sequence was developed and is presented in Figure 2.2.

Figure 2.2 is based on a merger between the stages concept of Norman and the feasibility evaluation process of the systems approach presented in Manetsch and Park [1979]. The sequence moves through a

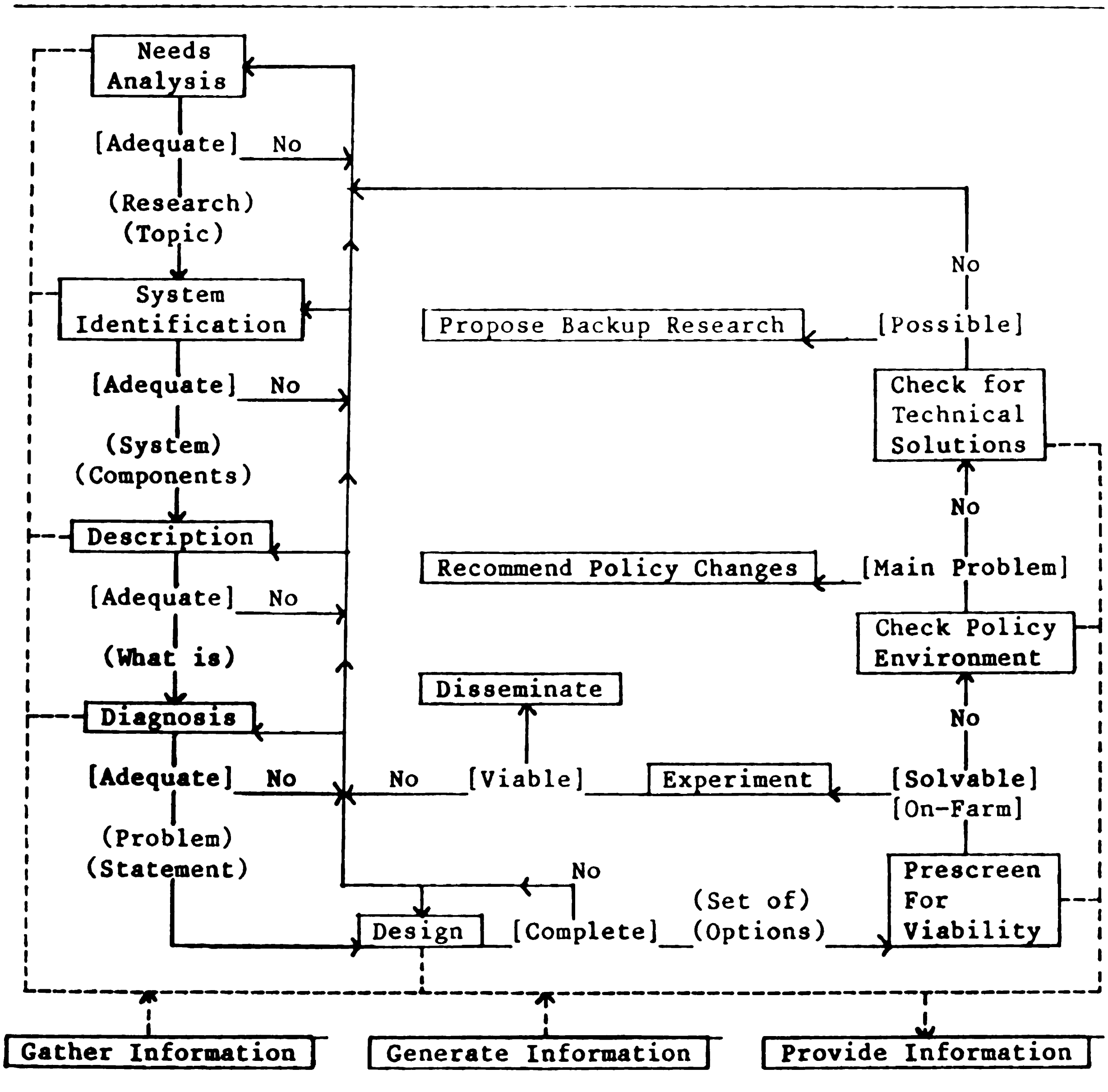

FIGURE 2.2: FARMING SYSTEMS PROBLEM EVALUATION SEQUENCE

series of processes (or stages). After each process, there is an evaluation to determine whether the outcome of the process was completed satisfactorily. The solid lines and arrows indicate the path through the processes. Reverse arrows indicate iteration or repetition of prior processes. The broken lines represent the accumulation and processing of information at all phases of the sequence. As represented in Figure 2.2, the collection, generation and provision of information are separate processes, which are outside but complementary to the actual problem evaluation sequence.

The sequence begins with a "needs analysis." The objective of the needs analysis is to select a research topic which addresses an identified need (or felt problem). The "need" can derive from a research mandate, a review of literature, intuition or an assessment of farmer problems, and usually will be based on a combination. The second process is to identify the system to be investigated. This process ordinarily starts with the farm system model. However, alternative systems can be identified depending on the needs analysis.

Two of the most important processes are systems description and diagnosis. Farming systems research procedures for systems description and diagnosis include the following steps. First, select areas and groups of farms systems with reasonably similar characteristics as targets for research. The target groups are called recommendation domains [Byerlee, Collinson et al, 1980] or research domains [Hildebrand and Poey, 1985]. Second, identify and describe systems components, management behavior, environmental circumstances, resource and demographic parameters, and performance measures. Third, examine subsystems management and the determinants of system performance in order to diagnose: (a) why practices are being used, (b) what problems constrain productivity, and (c) the relative importance of constraints.

In the design process, a range of alternatives are generated to address the identified constraints. The alternatives generally are based on experiment station research results, farmers' indigenous technical knowledge, and existing practices. The alternatives are prescreened taking into account technical feasibility, economic viability and social acceptability [Norman and Collinson, 1985].

The main design process output is a series of hypotheses about the technical and economic benefits from specific biological inputs, husbandry practices, practices by environment effects, or policy and institutional changes. The hypotheses are then tested through on-farm experiments or evaluated through policy and institutional research.

The problem evaluation sequence ideally encompasses attempts to test the validity of proposed solutions by having the clients of research react to them. The workability of solutions can then be judged by seeing if the clients take advantage of the findings and if, once adopted, the findings contribute to improved farm systems performance.

The problem evaluation sequence is not a one-time activity. There is continual iteration with respect to the processes in any given sequence. Also, new needs are identified over time. When a new need is identified, it might take priority over an existing problem evaluation sequence. In this case, the prior sequence is aborted, whatever information has been produced is distributed, and attention is shifted to the new needs analysis.

C. FIELD RESEARCH ACTIVITIES

This section describes: (a) the procedures used to select representative villages and farmer cooperators, (b) the surveys and studies used for systems description and diagnosis, and (c) the types of trials used to test production practices.

1. VILLAGE AND FARMER SELECTION

During the first three seasons, field research activities were focused on 52 farmer cooperators in two representative villages. Approximately half the cooperators participated in the resource monitoring survey (described below). Initially, only the other half participated in on-farm trials but, eventually, most of the cooperators hosted trials. All the cooperators also participated in several single-visit surveys. This section describes the procedures used to select the representative villages and farmer cooperators.

a. Village Selection In 1982

USAID and the GOB specified that the research coverage should be limited to a representative village in each of two extension areas. In conjunction with the District Extension Officers, three trips were made to identify and select representative villages.

The villages selected were Shoshong, in Mahalapye West District, and Makwate, in Mahalapye East District. Shoshong was selected to represent the dominant pattern of cattle and tractor farming. Shoshong is a large village with several active village groups, trading establishments and schools. Makwate was selected to represent donkey traction farming. In addition, Makwate has fewer services and less infrastructural development than Shoshong. Since Shoshong encompasses two extension areas, it was decided to work just in Shoshong East, one of

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of the two extension areas.

b. Farmer Selection

To select farmers, a three stage procedure was followed. First, village exploratory surveys were carried out to establish a research focus and define corresponding research domains. Second, a 16 question census was administered in each village to generate a sample frame. Third, nearly two months were spent contacting and interviewing the households selected from the sample frame, to make sure cooperators understood what would be expected of them.

The exploratory surveys were carried out during October 1982. Eight to nine person-days were spent in each village. The interviews were informal and unstructured. A checklist of information on practices and problems was compiled during the interviews. Debriefing meetings were held each evening.

The main arable production problem identified was inadequate and uneven plant establishment (based on a literature review and recommendations from on-station researchers, as well as the exploratory surveys). Therefore, research domains were defined on the basis of factors affecting the ability to implement timely planting or multiple tillage operations. Two RDs were identified. The domains were based on whether a household controlled the use of traction resources (owned, managed or borrowed) or was dependent on other households (hired or shared draft). Lack of draft control had been identified in several studies as the central constraint on timely planting and, consequently, as a key problem affecting crop production [FAO, 1974; Oland, Alverson, Cummings, 1980; Livingstone and Srivastava, 1980; Vierich and Sheppard, 1980].

The census was administered during late October and early November, 1982. Following a brief training session, nine enumerators covered both areas in two work-days. Eight additional person-days were spent recontacting households. Approximately 90 percent of the households were contacted in both villages.

The results of the censuses were hand tabulated so farmer selection could begin immediately. Independent samples were selected for the on-farm trials and resource monitoring so results of the resource monitoring survey would not be affected by participation in researcher managed trials. Based on available resources, it was possible to include approximately 25 households in the on-farm trials program and 25-30 households in resource monitoring. The size of the resource monitoring sample was based on an assessment that each of three enumerators could interview five households a day (or ten households total, each twice a week, with one day for recontacts).

Before selecting cooperators, each RD was divided into sub-domains. The first sub-division was based on type of traction used--donkeys, cattle or tractors. The type of traction was important to consider because of differences in expense, and the speed and quality of field operations (due to draft power). For the resource monitoring sample, an additional sub-division was made on the basis of cattle assets and gender of the household head. Cattle assets were considered since the research mandate was to focus on resource poor farmers. Also, cattle asset inequality had been a major agricultural planning issue in Botswana since the Rural Income Distribution Study (RIDS) [CSO, 1976]. Gender of the household head was considered because female-headed households had been identified as a particularly vulnerable segment of th

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the rural population [Bond, 1974; FAO, 1974; CSO, 1976; Kerven, 1977; Livingstone and Srivastava, 1980; CSO, 1982].

In order to make sure households representing each research domain and sub-domain were included, the population was stratified before randomly selecting cooperators within strata. The relative number of households selected in each stratum was determined by the number of households in each stratum in the population so results would not have to be weighted when presenting findings for each or both villages.

Some adjustments were made in the course of selecting each sample. For the trial cooperators, cell proportions were adjusted slightly to make sure there was minimal representation of each domain and traction sub-domain. Also, all members of the trials sample had to have fenced fields in order to protect trial plots. Two adjustments were made for the resource monitoring sample. First, households with only one or two members were not included, since a perspective of household resource allocation, not just for individuals, was wanted. Second, the sample in Shoshong East was clustered, since enumerators had to bicycle to the lands for interviews (a minimum of 10-15 kilometers). Once most farmers had been selected through the stratified random sampling procedure, clusters were completed by making contacts in the lands area. Farmers were interviewed at randomly encountered compounds. A household was included if it fitted the quotas based on draft access, traction, gender of household head, and cattle ownership.

By the middle of December, 1982, 52 cooperators had been selected, and both trial and survey activities initiated.

c. Addition of Makoro Village in 1984

Beginning the 1984-85 season, Makoro in the Palapye Agricultural District was added as a research village (following a GOB request to work in an additional district). To select Makoro, representative extension area characteristics were identified on the basis of a regional survey (see Chapter VI). The objective was to find a village which had less infrastructural development than Shoshong but, like Shoshong, represented the dominant pattern of cattle-tractor farming. The Ministry specified that the village had to be in Palapye District. Logistical considerations required that only villages within two hours of Mahalapye be considered.

Five potential villages were identified on the basis of survey results. Each village was visited once or twice. Makoro had all the specified criteria and provided a new settlement pattern. Although having a borehole, health clinic, general trader, extension agent, and various village groups, Makoro was a distant lands area for Serowe and Palapye villages.

2. SURVEYS AND STUDIES

Four types of surveys and studies were used for systems description and diagnosis: (a) resource use monitoring, (b) subject surveys, (c) plot monitoring, and (d) technical studies. A catalog of the surveys and studies, including the focus, reason, sample, dates and primary investigator for each activity, is presented in Table 2.1.

a. Resource Use Monitoring

Resource use monitoring was a major activity during the first three seasons. The primary resource monitoring instrument was the Multiple-Visit Resource Use (MVRU) Survey, which was administered from

TABLE 2.1: CATALOG OF SURVEYS AND STUDIES; OCTOBER, 1982 TO 1986

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.
Husbandry practices; Resource constraints; priority problems	Set research priorities and define RDs.	Village Exploratory Surveys	Oct 82	Around 50 farmers	FM/a
Distribution of resources & RDs in villages	Verify importance of RDs; sample frame	Sample Frame Census	Oct-Nov 82	90% hhs in Shos.& Mak.	FM
Cash flows, labor use, income & household maintenance activities; market and non-market exchanges	Identify resource constraints and opportunity costs; enterprise returns and coefficients	Whole Farm Multiple-Visit Resource Use Survey	Dec 82 Oct 84	27 hhs	FM
Relationship of cropping outcomes to timeliness of tillage-planting commonly practiced system	Determine circumstances required for successful standard plow-planting	Plot monitoring	1982-83 1983-84 1984-85	60+ farm-seasons	AG
Plowing situtions; social organization of plowing	Clarify factors affecting timely plowing	Draft Arrangements Survey	Feb-Mar 83	74 hhs	FM
Physical and chemical properties of soils	Identify soil constraints for crop production	Soil Variability Study	Feb 83 Jan 85	41 fields	AG
Activities & perceptions; extension problems; regional FS profile	Identify significant variations in project zone; constraints on ADs	Agricultural Demonstrator Survey	Mar-May 83	52 ADs	FM
Weed patterns	Identify weed problems in plow-planting system	Weed Assessment Survey	Mar-May 83	25 farms	AG

continued next page

Table 2.1 (continued)

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.
Crop enterprises and husbandry; farmers' views of resource constraints; food preferences	Baseline data on practices, problems, and perceptions to better assess research priorities	Crop Management Survey	May-Jun 83	116 hhs	FM
Planned cropping activities and practices; seed availability	Assess impact of drought on farmers' plans; farmer selection for trials	Cropping Plans Survey	Nov 83	45 hhs	FM
Household demographic structure; farm capital; livestock inventories and inventory changes	Analysis of resource parameters & relation to system performance	Household Inventory Surveys	Feb-Mar 84 and Feb-Mar 85	27 hhs 51 hhs	FM
Village traders & prices; government services and local group activities	Identify services and groups influencing farmer's decisions	Institutions, Infrastructure & Services Survey	Jan-Mar 84 and Jan-Feb 85	Shoshong & Makwate	FM FM
Soil profile patterns	Identify constraints	Soil-Rooting	Apr-May 84	10 fields	AG
Cowpea husbandry; product utilization; consumption patterns	Feed-back information to Sebele cowpea agronomy program	Cowpea Baseline Survey	Jun 84	49 hhs	FM
Labor, consumption, traction, exchange activities; livestock inventory changes	Compare frequency of farm activities for households with different characteristics	Activity Survey	Oct 84 Sep 85	51 hhs	FM

continued next page

Table 2.1 (continued)

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.
Crop, livestock and beer brewing inputs & outputs	Returns to key farm production activities	Abridged MVRU Survey	Nov 84 Oct 85	13 hhs	FM
Household demographics; intra-household roles; inter-household resource sharing; plow-planting practices; protection, harvesting, utilization practices; farmers' technical knowledge	Gain deeper insight in decison unit dynamics and farmers' indigenous technical knowledge and how these influence responses to technology recommendations	Decision Unit & Management Information Study	Oct-Dec 84 (Exploratory Survey)	2 villages	FM
			Feb-Jun 85 (Formal Surveys)	Average of 52 hhs	FM
Items sold & purchased; stocks; prices; problems	Assess market structure, conduct, performance	Trader Baseline Survey	Apr-Jun 85	163 traders; 49 Villages	FM
Livestock inventories, tending practices, and utilization patterns	Identify opportunities for increasing returns in livestock enterprises	Livestock Practices Survey	Sep-Oct 85	88 hhs	FM
Tractor use patterns; returns to contract hiring; maintenance and repair costs	Evaluate how tractor owners might provide a better service to tractor hirers	Tractor Record Keeping Study;	Oct 85 Jul 86	35 tractors	FM
		Tractor Owner Survey	Jul-Aug 86	22 Owners	FM
Cart ownership and use	Assess whether carts should be in ALDEP	Cart Use Survey	Jun-Jul 86	52 hhs	FM

a. Principal investigator: FM = farm management researcher; AG = agronomist.

December 1982 to September 1985. The MVRU Survey evolved during this period in the degree of structuring, primary objectives, and comprehensiveness.

During the first year, the survey was not pre-coded. Twice-weekly interviews were carried out with 27 farmers; 17 in Shoshong East and 10 in Makwate. The survey was designed to provide three categories of information: (a) crop production activities, including fieldwork by both household and non-household members, non-labor inputs, and traction use; (b) resource acquisition and disposal, covering sales, purchases, animal use, changes in livestock inventories, gifts and remittances, loans, and miscellaneous expenditures and receipts; and (c) household maintenance activities, including cooking, washing, gathering firewood, fetching water, compound construction and repair, and livestock tending. Initial attempts were made to collect information on travel, attending ceremonies, gathering wild food, and hunting, but these were generally not successful and, therefore, were abandoned.

Households were defined to include all individuals residing for most of the season at either the lands or village compound of the household, whether family members or not. In addition, all conjugal family members living outside the village area were defined to be non-resident household members if they had not yet established their own household. The distinction between resident and non-resident members was needed since transfers from non-resident members to resident members were recorded while transfers among resident members were not.

Information was collected from individuals who participated in activities. This generally meant that the respondents were women. In many cases, multiple respondents were interviewed so they could help each ot

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By the beginning of the second year, a structured, pre-coded survey instrument was developed. The survey instrument comprised a master questionnaire and 14 follow-up sheets which were collected and replaced each month. The master questionnaire had a series of "yes-no" questions on household activities. The follow-up sheets were used to record the flow data corresponding each activity.

During the third season, data were collected only on inputs and outputs related to arable production, beer brewing and livestock activities in the land/village area. The survey was administered to 13 households which had participated in the MVRU Survey in prior seasons. In general, these were farmers who had managed to produce some crops despite the drought conditions in 1982-83 and 1984-84.

To complement the 1984-85 MVRU Survey, an Activity Survey was carried out from October 1984 to September 1985. The survey provided a qualitative, seasonal profile of labor use, traction use, marketing and consumption activities for households with different characteristics. The sample for the survey was the cooperators selected in 1982. Farmers were asked on a monthly basis to recall the frequency with which an event took place during the month.

b. Plot Monitoring

During the first two seasons, plot monitoring was carried on fields of the trial participants and some fields of the MVRU Survey participants. During the third season, the number of fields and plots monitored was reduced. Eleven of the MVRU Survey participant's fields were monitored that season.

A plot was defined to be any contiguous area planted on the same day to the same crop or crop mixture. For each plot, data were collected on date(s) of plowing and planting, area, plowing rate and depth, soil moisture, seeding rate, seed quality, tillage and planting method(s) used, and weed level. Rainfall data were collected on a field by field basis. Production responses included plant emergence counts, harvest plant counts, and grain yield. Yield loss estimates for bird feeding, smut in sorghum, and cattle and wildlife feeding were made from harvest samples.

c. Subject Surveys

The term "subject survey" was used to distinguish topical single-visit surveys from the MVRU Survey. From 1983 to 1986, thirteen formal subject surveys were designed and carried-out. The general objective of these surveys was to broaden understanding of the circumstances affecting farm systems decision making and performance. The following surveys were administered:

1) 1983: Draft Arrangements; Crop Management; Agricultural Demonstrator; and Cropping Plans (for 1983-84 season) surveys.
2) 1984: Village Institutions and Services; and Cowpea Baseline surveys.
3) 1985: Trader Baseline; Management Information for Plow-Planting; Decision Unit Profile; Crop Protection, Harvesting and Utilization; and Livestock Practices surveys
4) 1986: Tractor Ownership and Use; and Cart Use surveys.

The farmer cooperators were the core sample for the Draft Arrangements, Crop Management, Cropping Plans, Cowpea Baseline and Livestock Practices surveys. In the Draft Arrangements Survey, the cooperators were supplemented with 11 randomly selected farmers in

Makwate (to make the sample from the donkey village comparable to the cattle-tractor village) and 13 purposively selected households involved in cooperative plowing arrangements. The last set was included in order to have a sufficient sample size for evaluating cooperative arrangements.

The most important subject survey was the 1983 Crop Management Survey. To analyze the representativeness of the cooperators, 66 randomly selected farmers were interviewed as well as the cooperators; 38 in Shoshong East and 28 in Makwate. As many as possible of the cooperators and randomly selected households were interviewed again for the 1985 Livestock Practices Survey.

Participants in the three surveys of the 1985 DUMI Study (Management Information for Plow-Planting; Decision Unit Profile; Crop Protection, Harvesting and Utilization) comprised a quota sub-sample of 52 households selected from among the 66 randomly selected households which participated in the 1983 Crop Management Survey. The overlapping sample was used to allow an evaluation of cropping trends. Cooperators were not included in the DUMI Study since participation in trials may have influenced their managerial practices and attitudes.

The Agricultural Demonstrator Survey was based on a questionnaire distributed to all the ADs in the Central Region at their monthly management meetings in March, 1983. ADs returned the questionnaire though the mail. After a questionnaire was returned, each AD was interviewed in order to eliminate mistakes. Eventually, questionnaires were received from 52 of 54 ADs.

In the Trader Baseline Survey, 173 trading establishments were enumerated in 49 villages, nearly all the villages in the Central Region except for

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except for Bobonong District. (Bobonong had by then been excluded from the research mandate zone.) All traders were interviewed in 46 villages, while a subset of around 15 traders per village were randomly selected from the three major villages (Mahalapye, Serowe, and Palapye).

In addition to the formal subject surveys, many informal (rapid appraisal) and end-of-season trial assessment surveys were carried out following the subject survey format.

d. Technical Subject Studies

Several technical studies were carried out in order to describe particular characteristics of the physical environment pertinent to arable production. These studies included direct measurements and observations, as well as analyses of secondary data.

Technical subject studies addressed the following: (a) soil variability, (b) weed burdens and composition in cultivated fields, (c) soil profiles in relation to the depth of sorghum rooting, (d) vegetation cover, soil types and topography in the project area, (e) rainfall, temperature and evapo-transpiration during the four seasons of field research, and (f) long term rainfall probabilities based on data from the Department of Meteorological Services.

3. EXPERIMENTATION

Many trial designs were used for experimentation. The number of treatments and replications varied depending on the trial objectives and the degree of researcher versus farmer involvement. In some cases, there were replications within farms and in other cases only between farms.

During the first two seasons, most experiments were researcher managed and farmer implemented, following standard farming systems researc

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research guidelines. Beginning the third season, several approaches, involving different combinations of researcher and farmer management, were used. The relative importance of researcher managed and implemented trials increased overtime, rather than decreased, because: (a) pressure from the drought made it difficult for farmers to implement trials and (b) the experimentation program increasingly focused on technology design rather than final stage testing. After the third season, essentially all farmer implemented trials were also farmer managed.

A catalog of the trials carried out during the four seasons of research is given in Table 2.2. The types of trials carried out can be categorized as follows:

a. Factorial design trials. Factorial experimental designs, involving split and strip plots, were used in order to evaluate component technologies and technology by environment effects. These trials were researcher managed and implemented and included within-site replications.

b. Informal design studies. Informal investigations depended on subjective farmer and researcher evaluation of interventions. These usually were evaluations without comparison checks.

c. Superimposed trials on farmers' plots. Treatments generally were researcher implemented on farmers plots. In cases where the primary objective was to assess technical responses, two to four replications per site were implemented. In cases where economic analysis (and/or farmer assessment) was the main objective, fewer within-site and more between-site replications were used.

d. Researcher managed tillage-planting (including crop-variety)

TABLE 2.2: CATALOG OF ON-FARM EXPERIMENTS; OCTOBER, 1982 TO 1986

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.

TABLE 2.2: CATALOG OF ON-FARM EXPERIMENTS; OCTOBER, 1982 TO 1986

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.
Recommended tillage, planting & phosphate practices	Screening for environmental interactions and synergistic effects	Phosphate Strips	1983-84	13 farms	AG
		Commercial Steps In Technology	1984-85 1985-86	9 season-locations	AG
Effects of early plowing on plant establishment & crop development	Water conservation to benefit germination & seedling vigor	Double Plowing	1982-83 1985-86	2 farms 25 farms	AG
Crop residues	Crop residues are insufficient in dry years	Sorghum Intercropping;	1982-83	1 site	AG
Tillage-planting equipment	Improve establishment with few extra resources	Investigation of Plow-Planter	1982-83 1983-84	9 farmers	AG
Control of bird damage	Feeding causes damage; to reduce scaring labor	Bird Scaring Ribbon Scheme	1983-84	4 sites	AG
Seed treatments	Improve seed viability	Seed Treatment	1983-84	16 farms	FM
Effects of early plowing & planting methods on establishment, development & weeds	Need planting methods for early plowing; to incorporate more tillage into system	Tillage-Planting Scheme	1983-84 1984-85	9 reps 7 farms	AG
		Row Planting	1985-86	7 farms	
Secondary crop establishment & yield	Inter-crop and intervarietal variability	Cropping Comparison	1983-84 1984-85	37 farms	AG

continued next page

Table 2.2 (continued)

Table 2.2 (continued)

FOCUS	REASON	ACTIVITY	DATES	SAMPLE	INVES.
Use of corral manure	DAFS recommendation	Intensive Production 2	1984-85	5 farms	AG
Watered garden plots	Need for off-season produce	Intensive Production 1	1984-85	7 farms	AG
Hand undersowing large seeded grain crop	Need for gap-fill, late planting option	Undersowing	1984-85	9 farms	AG
Donkey draft management	Identify problem areas	Draft Management	1984-85	1 village	AG
Hand row planting vs. broadcasting four cowpea varieties	Evaluate whether one or more varieties are not good for broadcast planting systems	Cowpea Planting Methods-Variety Trial	1984-85	8 farms	FM
Water conservation tillage-planting systems	Proposals from secondary sources, soil moisture is major constraint	Water Conservation Trial	1985-86	3 sites	AG
Sole planting of high value secondary crops	Farmer and researcher assessment of sole planting selected crops	Sole Planting Trial	1985-86	33 farms	FM
Replanting sorghum & millet with sanitas hand planter	Assess the implement and gap filling to achieve more even stands	Gap Filling Trial	1985-86	12 farms	FM
Thinning heavy sorghum & millet stands	Asses the advantages of eliminating high stands	Thinning Trial	1985-86	5 Farms	FM

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comparisons with farmer implementation. This was the most common trial format. Tillage-planting practices were researcher specified and managed. Farmers implemented the tillage-planting operation and were responsible for all non-treatment aspects of the trial. A traditional check plot nearly always was included.

e. Farmer managed and implemented trials. All managerial decisions were left up to farmers and few measurements were made to formally assess outcomes. This format was used when the primary interest was: (a) researcher assessment of problems encountered with new implements or (b) farmer assessment of practices or varieties.

D. DATA ANALYSIS

Most survey data analysis was based on evaluating significant mean differences (for quantitative variables) or deviations from cell expected values (for categorical variables) across household type or gender categories. The design of all survey forms took into account the anticipated analysis based on household types. Index variables were included on each questionnaire for the strata assignment of each sampled household.

The main stratifying variables were: (a) village, (b) type of traction used, (c) draft access, (d) gender of head of household, and (e) cattle owned. Type of traction referred to the primary source of traction, and distinguished among donkey, cattle and tractor. Gender of head was based on the de facto head. (Some male heads were not resident in the lands/village area and a female was the de facto household head with respect to farm systems management.) The categories for draft access were: owned, borrowed or managed, hired, or obtained through a cooperative arrangement. Five levels were distinguished for cattle owned:

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owned: 0, 1-15, 16-35, 36-70, and more than 70.

During data analysis, the stratifying variables generally were recategorized on the basis of statistical "rules-of-thumb." For calculating means, the target was to have 20-30 observations per mean. For contingency analysis, the target was to have an expected value of at least five per cell. Aggregations were made as necessary to approach these targets.

Given the small sample sizes for many subject surveys, the index variables generally were categorized to take on only two values. For draft access, draft owners and borrowers were treated as draft-controlling households. Hiring households and households which obtained traction through cooperative arrangements were treated as draft dependent. Two approaches were taken for dividing households on the basis of cattle assets. For most subject surveys, 15 cattle was used as the breaking point. This was the nearest break to the median number of cattle owned. For analyzing the resource monitoring data, 36 cattle was used at the breaking point since was close to the 40 head of cattle used by the GOB to determine eligibility for ALDEP.

The collection of labor flow data anticipated gender and age disaggregated analysis, as well as analysis based on the household strata. Separate sheets were used to record the labor times for household and non-household members.

To reduce the number of records, labor data were recorded only on the basis of the number of men, women, boys and girls working on an activity, and the length of time worked. The adult, non-adult division was based on the year of independence, 1966, since this was easy to recall. To give an example of the approach: if one man and two boys

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spent three hours plowing, a single line was used to record: "1" under "days" for men, "3" under "hours per man," "2" under "day" for boys, and "3" under "hours per boy." One advantage of the approach was that multiple days of work could be recorded on a single line. Thus, for example, if one woman spent an average of two hours per day cooking during the three days since the last interview, the enumerator could record "3" under "days" (one woman times three days) and "2" under "hours per day" for women.

Revenue and Expenditure data also were combined in the field to reduce the number of records. The following categories were used for expenditures: production inputs, grain and meal, other food, animals and animal products, household goods, gifts and loans, wages, transport, and other. The categories used for revenues were: crop sales, livestock sales, beer sales, other sales, gifts and loans, wages, and other. The field aggregations were particularly useful for purchases since many types of "other food" often were purchased at the same time and respondents could more easily remember the total than they could the prices of individual items.

Because of the data collection approach, it was possible to analyze most of labor and expenditure data using only database management software. This was valuable since no software was available for creating aggregated data files, and the available statistical software had limited memory capacity.

The trials data were analyzed using analysis of variance or paired t-tests. Because of the drought, trials data analysis often focused on intermediate cropping outcomes instead of yield. Emergence stand counts and the percentage field emergence were the main intermediate cropping

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outcomes analyzed. (Percentage field emergence is based on the emergence stand counts divided by the number of seeds planted.) For tillage-planting trials, the effects of treatments on weed burdens (measured as the percent field coverage by weeds) also was an important dependent variable.

Economic assessments of trial outcomes relied on partial budgeting. This was possible since the interventions analyzed required minor changes in resource allocations and no changes in the end-use of products. An attempt was made to value resources at their local market prices.

E. DISTINCTIVE FEATURES OF THE RESEARCH APPROACH

The research approach has four distinctive features: (a) it is a non-modernist approach, (b) has a subject matter rather than a problem solving orientation, (c) is based on a farmer first planning perspective, and (d) is broader than is typical for farming systems research.

1. NON-MODERNIST

The research approach used in the thesis represents an attempt to operationalize the concept of non-modernist research, as characterized by Glenn Johnson [Johnson, 1983]. Non-modernist research is very similar to systems analysis in that it is multidisciplinary, expansionist, teleological and pragmatic. Non-modernist research also tends to be eclectic with respect to research methods, relying on comparative analysis, descriptive statistics and hypothesis testing rather than quantitative analytical models.

Following Johnson, modernist research is based on the view that: (a) explanation is derived from scientific laws, (b) knowledge not expressi

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expressible in numbers is inadequate, and (c) evaluating the accuracy of predictions based on theory is the main goal of research. Non-modernist research is based on the view that the theories of any single discipline are not a sufficient framework for addressing real world problems. With respect to farm management research, the non-modernist perspective holds that research focused on technologies and institutions, and human performance in adjusting to new technologies and institutional change, is more relevant to farm managers, extension agents and planners than are econometric and mathematical programming models focused on static optima.

Johnson's concerns with modernism date to the 1950s when he first argued that "management (including farm management) cannot be defined, abstractly or in practice, as only a subfield of economics" [Johnson, 1957: 442]. In both 1952 and 1957, Johnson posited that managers are concerned with many types of information not commonly regarded as economic in nature, of which the most important are institutional arrangements and technological change.

In 1983, Johnson cited several examples from the post-war history of farm management research which illustrated the difficulties encountered when attempting to use modernist methods to address agricultural development problems. In contrast, Johnson cited other examples in which non-modernist research did provide information of relevance to farm managers, extension agents and planners.

Based on the American farm management research heritage, Johnson [1982] argued at the 1981 Kansas State University Farming Systems Research Symposium that the top priority for farming system researchers was to carry out non-modernist research on: (a) farm-household relatio

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relationships, (b) values and preferences, (d) induced institutional and human change, (d) managerial processes, and (e) policy changes needed to promote agricultural development.

2. SUBJECT MATTER ORIENTATION

Johnson [1983] also has clarified the distinction between problem solving and subject matter research. The purpose of problem solving research is to solve specific problems facing specific decision makers. The purpose of subject matter research is to provide information on sets of problems to sets of decision makers. As Johnson notes, problem solving requires simultaneous attention to all variables defining a problem and necessary for its solution.

This research follows a subject matter orientation for several practical reasons. First, the top priority in Botswana is to improve the general capacity of the Ministry to address a multitude of problems constraining arable crops development, not the solution of any single problem. Second, the research is based on village and farm-level surveys and experimentation and, therefore, does not encompass a holistic enough perspective to actually solve arable farming development problems. The solution of these problems would require macro level analyses that go beyond the mandate of the Ministry of Agriculture. Third, the research was carried out in isolation from the relevant decision makers for agricultural policy in Botswana. Without a needs analysis and diagnosis involving direct input from decision makers, the requirements for problem solving research could not be met.

3. FARMER FIRST PLANNING PERSPECTIVE

A key postulate of the farming system approach is that planning for agricultural development must start with an understanding of existing farming patt

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farming patterns [Collinson, 1972; Norman, 1980]. This postulate is based on an accumulation of experience in farm-level research which shows that farmers have indigenous knowledge [Brokensha, Warren, Werner, 1980], experimentation procedures [A. Johnson, 1972] and adjustment processes [Collinson, 1968] which they use to cope with an uncertain technical and institutional environment.

Aside from a general consensus on "the need to understand existing systems," there are differences in farming systems research approaches regarding the roles of farmers. Through the early 1980s, most farming systems research focused on evaluating the technical feasibility and economic viability of modified practices and varieties. Farmers often had a passive role. Farmers were the clients of research [Gilbert, Norman, Winch, 1980] and generally implemented the trials, but the real goals of research were agronomic and economic analyses of input-output relations and profitability [Byerlee, Harrington, and Winkelmann, 1982]. Researchers assumed the role of decision maker.

In reaction, a number of FSR social scientists recently have been promoting a "farmer first" approach to farming systems research [Rhoades and Booth, 1982; Chambers and Ghildyal, 1985]. In the farmer first model, farmers are involved in all research processes and their perspectives dominate the problem evaluation sequence.

The research approach in this thesis is distinct from both of the above. A farmer first viewpoint is adopted with respect to the importance of farmers' perspectives, since ultimately it is the farmers' decisions that matter--not researchers' decisions. On the other hand, farmers are only indirectly considered to be the clients of the research. The direct clients of the research are the planning, research and extension personnel of the Ministry of Agriculture.

The thesis emphasizes the Ministry of Agriculture for two reasons: (a) research and development efforts focused on particular farmers in particular areas often do not spread to other farmers and (b) arable farming development will take a long time in Botswana. In the long run, the capacity of the Ministry to facilitate development is more important than short run improvements in farmer welfare (given the various assistance programs which buffer farmers against the worst effects of drought and low production [Holm and Cohen, 1986]).

4. SCOPE OF RESEARCH

Despite the broad conceptual framework of the farming systems approach, farming systems research projects and programs often have ignored local institutions (support systems) and household dynamics. The guidelines for FSR emphasize cost- and time-efficient research methods. For example, Gilbert, Norman and Winch [1980] recommended that minimal investments should be made in information gathering; just enough to develop the understanding needed to design and test production technologies. Collinson [1982] recommended focusing on one or a few activities or enterprises which most affect overall farm systems performance ("leverage points"). In general, more attention has been given to how quickly diagnosis could be completed and testing started than to the quality of results obtained.

After a great deal of early enthusiasm, questions started emerging, in the mid-1980s, about the potential of "quick and efficient" farming systems research methods. C. Eicher [1986], among others, argued that the scope of FSR was too narrow to have a significant impact on the deteriorating agrarian situation in Africa. A second argument held, insteac

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instead, that the potential of the farming systems approach was still unknown because farming systems research methods had deviated so much from a true systems perspective.

Two approaches have been taken to address the perceived weaknesses of the farming systems approach. One has been to reject the farming systems approach in favor of other systems, including agro-ecological systems [Gibbs, 1985], agro-forestry systems [Rochelieu, 1986], and food systems [Riley and Staatz, 1981]. The second approach has been to abandon the emphasis on production technologies and quick turnaround time in favor of systems research methods which more adequately address intra-household dynamics [McKee, 1984; Moock, 1986; Feldstein and Poats, 1985], inter-household linkages [Behnke and Kerven, 1983], consumption perspectives [Frankenberger, 1986], and the requirements for national development planning [Norman and Baker, 1984].

Since the problem addressed in this research relates to the requirements of the Ministry of Agriculture, and since the Ministry has been directed to use the farming systems research methodology [MFDP, 1985], this thesis has followed the second approach. An important contribution of the thesis, therefore, is to illustrate a broader approach to farming systems research.

III. HOUSEHOLD CIRCUMSTANCES AFFECTING ARABLE FARMING

This chapter gives an overview of household and farm system structure and resource use in Shoshong and Makwate villages. The first section is on household demographics. Section two characterizes household wealth, including livestock inventories and farm fixed capital. The next three sections describe household labor use, cash revenues and expenditures, and food consumption. The final section points out the implications of household and farm system circumstances for arable farming development.

There are two main objectives to the chapter. The first is to give a profile of household circumstances in order to place arable farming into a broader household and farm systems context. The second is to analyze differences in circumstances for: (a) households in Shoshong versus households in Makwate, (b) male-headed versus female-headed households, (c) cattle-rich versus cattle-poor households, and (d) draft-dependent versus draft-controlling households.

A. HUMAN RESOURCES

Information on household demographics was collected in household censuses administered yearly to the MVRU Survey participants. The primary objective was to characterize the human resources available for crop production activities. The 1984 census revealed around 12 members per household, of which ten were in residence. In contrast, many of the studies from the 1970s reported only 7-8 resident members (for example, Fa

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FAO [1974], Bond [1974], CSO [1976]). No significant differences in household size were associated with village, gender of household head, draft access or cattle assets.

To assess consumption requirements, resident consumer units were derived using adult caloric requirements to weight individuals of different ages. Overall, households had to feed just over seven adult consumer units. Makwate households had more consumer units but otherwise there were relatively small differences associated with the household categories.

Since human resources are a key farm system parameter, the census data were used to examine three demographic issues: (a) age and gender composition of the farming population, (b) main activities of the population besides crop production, and (c) residential patterns at different periods of the year.

1. HOUSEHOLD COMPOSITION

There are age and gender specific production roles in most African societies [Boserup, 1970]. Consequently, differences in the age and gender compositions of households often are related to resource use patterns and farm systems performance. Information on the gender and age composition of households is presented in Table 3.1.

The age and gender compositions of the household categories were similar. Approximately 45 percent of resident members were adults. Girls (under 16) were particularly prevalent in cattle-poor and female-headed households. A larger proportion of household members were boys in Makwate than Shoshong East, reflecting the fact that fewer

TABLE 3.1: HOUSEHOLD STRUCTURE, 1983-84

VILLAGE		SEX OF HEAD		CATTLE ASSETS		DRAFT ACCESS		
SHOSHONG	MAKWATE	MALE	FEMALE	36+	0-35	OWN	DEPENDENT	ALL

TABLE 3.1: HOUSEHOLD STRUCTURE, 1983-84

	VILLAGE		SEX OF HEAD		CATTLE ASSETS		DRAFT ACCESS		
	SHOSHONG	MAKWATE	MALE	FEMALE	36+	0-35	OWN	DEPENDENT	ALL
HOUSEHOLD SIZE:									
All Members	11.8	12.6	11.6	12.8	10.5	13.2	12.4	11.6	12.1
Local Residents	9.4	10.9	9.5	10.7	8.8	10.6	9.9	9.9	9.9
Percent Resident	79	83	79	83	73	85	82	82	81
AGE-GENDER COMPOSITION ALL MEMBERS (%):									
Men	23	22	24	21	25	21	24	21	23
Women	22	20	20	23	21	17	20	23	21
Boys	22	31	29	21	31	23	29	20	26
Girls	33	26	27	35	23	35	27	36	31
AGE-GENDER COMPOSITION RESIDENTS (%):									
Men	15	13	16	13	16	14	14	12	15
Women	21	23	22	22	21	22	20	23	22
Boys	26	33	32	24	36	25	34	22	29
Girls	38	31	30	42	26	40	32	43	35
COMPOSITION BY RELATION TO HEAD (%):									
Head	9	8	9	8	9	8	8	9	9
Spouse	6	6	9	2	7	6	7	4	6
Child	50	49	56	41	51	49	54	43	50
Grandchild	19	29	17	31	18	25	23	22	23
Other Relative	14	9	8	18	12	11	6	23	12
Non-Relative	3	0	3	0	4	0	3	0	2
CONSUMER UNITS/a:	6.6	8.2	7.3	6.9	7.2	7.2	7.5	6.5	7.2

Source: 1984 Household Census; 27 MVRU Survey households, 315 people enumerated.

a. Consumer unit weights: age 0-4 = 0.20; age 5-9 - 0.50; age 10-15 = 0.75; adult women = 0.90; adult men = 1.00.

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Makwate households had distant cattle posts.

Differences in age and gender compositions were more pronounced when focusing just on resident household members. Men only constituted 15 percent of the resident population compared to 22 percent for women. In female-headed, cattle-poor and draft-dependent households, resident women outnumbered resident men by an average of around 70 percent. These households also had a relatively large of their populations comprised of young grandchildren. Similar effects of temporary migration on household composition were noted in FAO [1974] and CSO [1982].

2. MAIN ACTIVITIES

In the Central Region, crop production usually does not provide labor returns which are comparable to wage employment. Therefore, involvement in wage employment, or even schooling (since that is the route to wage employment) must be considered a parameter for the crop production subsystem. Thus, an important demographic issue is who considers farming to be their main activity. Findings on this issue are summarized in Table 3.2.

Crop production was the main activity of only 25 percent of the population. A quarter of the population were going to school, another quarter were too young or too old to be active, and 19 percent said that wage employment was their main activity. Differences across household types were relatively small. Female-headed and poorer households did have a slightly higher proportion of individuals involved in wage employment, while male-headed and cattle-rich households had more who considered herding to be their main activity.

More substantial differences were found when looking at main

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TABLE 3.2: MVRU SURVEY PARTICIPANTS' MOST IMPORTANT ACTIVITIES, 1984

	FARM	HERD	STUDENT	EMPLOY-MENT	NOT ACTIVE
	(Percent of Population)				
HOUSEHOLD TYPE					
VILLAGE:					
Shoshong	27	6	24	17	25
Makwate	22	3	27	20	27
SEX OF HEAD:					
Male	27	6	26	16	25
Female	24	3	24	21	28
CATTLE ASSETS:					
0-35	24	3	23	20	30
36+	28	8	29	15	20
DRAFT ACCESS:					
Control	26	6	26	17	25
Dependent	25	3	25	18	28
PERSONAL					
AGE-SEX:					
Men	39	4	3	53	1
Women	69	0	5	20	6
Boys	4	14	41	1	40
Girls	3	1	44	3	47
EDUCATION:					
0-6 Years	23	5	26	11	35
7+ Years	25	5	25	19	26
ALL	25	3	25	19	26

Source: 1984 Household Census.

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activities in relation to age and gender. Nearly 70 percent of women said crop farming was their main activity compared to only 39 percent of men. More than half the men said wage employment was their main activity. The main activity for boys, aside from being students, was herding.

3. RESIDENTIAL PATTERNS

There are two major migration patterns in Botswana. One is emigration from the lands or village area to seek employment. The second is seasonal migration between the village and lands at the beginning and end of the cropping season. Much has been written about these migration patterns; a major national study assessing migration was completed in 1982 [CSO, 1982]. One major conclusion was that seasonal migration is declining. A reduction in seasonal migration, in favor of permanent lands settlement, would remove a major constraint on crop systems development by creating an opportunity for off-season field operations [Livingstone and Srivastava, 1980]. To assess the significance of seasonal migration in Shoshong and Makwate, data were collected on the principal residence at different periods of the year. Findings are summarized in Table 3.3.

In 1984, there was a substantial amount of seasonal migration between the village and lands area. During the cropping season, approximately half of the population moved to the lands. Most of those remaining behind in the village were school age children. The proportion of individuals remaining in the village was higher in Makwate because the lands areas are close to the village. Several households in Makwate commute on a daily basis rather than make a seasonal migration.

Few individuals had taken up permanent residence in the lands area.

TABLE 3.3: PRINCIPAL RESIDENCE BY PERIOD, 1984

TABLE 3.3: PRINCIPAL RESIDENCE BY PERIOD, 1984

	CROPPING SEASON				DURING WINTER			
	VILLAGE	LANDS	CAT.POST	OUTSIDE	VILLAGE	LANDS	CAT.POST	OUTSIDE
	(Percent of Population)							
HOUSEHOLD TYPE								
VILLAGE:								
Shoshong	28	50	1	21	69	7	2	21
Makwate	40	43	0	18	81	0	0	19
SEX OF HEAD:								
Male	31	49	1	19	73	5	2	20
Female	34	45	1	21	75	2	2	21
CATTLE ASSETS:								
0-35	38	43	1	19	79	2	1	19
36+	22	54	1	22	65	9	3	22
DRAFT ACCESS:								
Control	28	50	1	22	74	2	3	22
Dependent	38	43	1	19	72	9	1	18
PERSONAL CHARACTERISTICS								
AGE-SEX:								
Men	10	39	3	48	44	1	6	50
Women	25	55	0	20	76	5	0	20
Boys	33	56	0	12	77	10	3	12
Girls	52	41	0	7	92	1	0	7
EDUCATION:								
0-6 Years	36	52	§1	12	82	4	2	12
7+ Years	20	35	1	44	49	4	1	55
ALL	32	47	1	20	74	4	2	20

Source: 1984 Household Census.

Also, few considered cattle posts to be their principal residence at any time of the year. On the other hand, around 20 percent of the population resided outside the lands/village area during all periods of the year. To the extent seasonal migration had declined in Shoshong and Makwate, it appears it had declined due to permanent rural-urban migration rather than permanent lands area settlement.

B. LAND, CAPITAL AND LIVESTOCK RESOURCES

This section presents an overview of household land, capital and livestock resources. The first part gives a profile of resource control based on the 1983 Crop Management Survey. The second part presents a more detailed analysis of the composition and value of the MVRU Survey participants' assets.

1. RESOURCE PROFILE, 1983

In the 1983 Crop Management Survey, resource data were collected on cattle assets, major implements, land availability and field characteristics. Results are summarized in Table 3.4.

Substantial differences were identified in cattle assets. Fewer Makwate, female-headed, and draft-dependent households had cattle than did Shoshong, male-headed and draft-controlling households, respectively. Those Makwate, female-headed and draft-dependent households which did have cattle, tended to have fewer cattle. Although substantial, the extent of cattle asset inequality in the Crop Management Survey population was less than that reported in the FAO [1974] and RIDS [CSO, 1976] studies. In both those studies, 45 percent of the households had no cattle and, in the RIDS, the poorest 50 percent of households only had 0.5 percent of the cattle.

The differences by household types noted with respect to cattle

TABLE 3.4: CATTLE, EQUIPMENT AND LAND RESOURCES, 1983

		VILLAGE		SEX HEAD		CATTLE		DRAFT ACCESS	
	ALL	SHOS.	MAKW.	MALE	FEMALE	0-15	16+	CONTROL	DEPEND
CATTLE									

TABLE 3.4: CATTLE, EQUIPMENT AND LAND RESOURCES, 1983

		VILLAGE		SEX HEAD		CATTLE		DRAFT ACCESS	
	ALL	SHOS.	MAKW.	MALE	FEMALE	0-15	16+	CONTROL	DEPEND
CATTLE									
AVERAGE NUMBER:									
Owned and Managed	32.4	43.5	9.1	38.3	15.9	3.1	57.6	38.9	16.5
Owned, Not Managed	2.9	3.7	1.6	3.4	2.0	0.4	5.5	2.7	3.0
Managed Only	2.8	3.8	1.5	4.4	0.6	0.8	5.0	4.6	0.5
PERCENT HH OWNING:									
0	29	15	50	19	45	56	0	20	41
1-15	23	26	19	20	28	44	0	23	24
16-35	21	22	19	26	13	0	44	25	16
36+	26	37	12	35	15	0	56	32	20
EQUIPMENT									
AVERAGE NUMBER	1.1	1.2	1.0	1.4	0.6	0.6	1.6	1.4	0.7
PERCENT HH WITH:									
0	33	28	40	17	58	49	16	21	50
1 or 2	57	58	55	68	40	48	65	64	46
3+	10	13	4	14	2	2	18	15	4
LAND									
YEARS FIELD CULTIVATED	21.3	25.5	15.6	22.0	20.3	19.3	23.5	19.5	23.6
HAVE UNUSED LAND (% HH)	45	50	38	49	38	53	36	40	51
SEASONS IN 10 USE ALL LAND	4.8	3.9	6.2	4.6	5.1	4.9	4.7	5.6	3.9
EVER BORROW LAND (% HH)	15	13	17	17	11	11	16	17	12
DESTUMPING OF FIELD (% HH):									
Complete	39	33	47	44	30	33	45	43	33
Partial	61	67	53	56	70	67	55	57	67
FENCING OF FIELD (% HH):									
Wire	42	33	53	49	30	28	57	52	29
Bush	21	21	21	16	28	25	17	17	27
None	37	45	26	34	41	47	26	31	45

Source: 1983 Crop Management Survey; 116 households.

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assets were also found for equipment ownership. Fewer Makwate, female-headed, cattle-poor and draft-dependent households owned equipment than their counterparts, and the average numbers of pieces of equipment owned were less.

To a slightly lesser extent, similar differences were again identified for land resources. More male-headed, cattle-rich and draft-controlling households had completely destumped and wired fenced fields than had their comparison households. However, there had been more wire fencing in Makwate than in Shoshong. Fields had been cultivated longer in Shoshong East than in Makwate but differences field age between households categories were insignificant.

In both villages, land allocations were completely used in five seasons out of ten. Less than half the households reported they had unused land in good seasons. Few draft-controlling, cattle-rich or Makwate households had unused land in good seasons.

2. COMPOSITION AND VALUE OF FARM ASSETS, 1984

In 1984, two inventory surveys were administered to the MVRU Survey participants in order to develop a more detailed picture of household resources. One survey covered livestock inventories. The other was on farm fixed capital, including buildings, field characteristics, implements, hand tools and receptacles. This part presents selected findings on the composition and value of farm assets.

a. Farm Fixed Capital

All households had access to at least one field; 22 percent had access to a second field. On average, the current heads of households obtained their fields twenty years ago. More than half the fields were obtained via inheritance. However, nearly half the fields in Shoshong

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East and more than a third overall were initially opened (destumped and/or fenced) by the current household head. A small proportion of fields were borrowed or were obtained as gifts. Borrowing land was more common in Makwate than in Shoshong, and for cattle-poor and female-headed households relative to cattle-rich and male-headed households.

Most households had one single-furrow mouldboard plow. Nineteen percent had no plow while 22 percent had two or more plows. Over 60 percent of the plows owned were purchased more than 20 years ago and only half the plows were purchased new.

Most households had a variety of hand tools, usually including axes, hoes, and spades. Thirty percent or more households had picks, rakes and augers. Most households also had several types of receptacles, usually including small and large buckets, large bowls, and one or more drum and large plastic containers. Only ten percent of households had a wheelbarrow, despite the potential value of wheelbarrows in reducing time spent fetching water. The proportions of households having the various hand tools and receptacles were comparable for households in the two villages and across household categories.

Households had on average more than five buildings; just under two on in the lands area and around four in the village. All Shoshong East households had buildings in the village and the lands area. Several Makwate households did not have lands area buildings. Village buildings generally were better constructed and require a larger investment per building.

b. Livestock Inventories

Just over 85 percent of the households owned some cattle. Nearly all owned chickens and 85 percent own goats. Less than half owned donkeys, a quarter owned sheep and none owned either horses or pigs.

Patterns of cattle ownership followed those identified in the 1983 Crop Management Survey. For goats, there were differences by village in the proportions of households owning and the average numbers owned, with more Shoshong households owning. There were no significant differences by household type. The FAO [1974] study also showed that differences in smallstock ownership were less skewed than was cattle ownership. No significant differences were found for chicken ownership or average chicken inventories by village but male-headed, cattle-rich and draft-controlling households had 50-100 more chickens than their comparison households. Donkeys were more commonly owned by Makwate, male-headed and draft-controlling households. Relatively more male-headed households owned sheep.

c. Value of Farm-Household Assets

Values of livestock inventories and farm fixed capital for MVRU Survey participants are presented in Table 3.5. Overall, households had around P10,000 in assets. Shoshong East, male-headed, cattle-rich and draft-controlling households all had greater assets, largely due to livestock assets. These same households consistently achieve higher levels of arable crops production (see Chapter V).

A substantial proportion of assets were tied up in buildings, particularly village buildings. This was particularly true in Shoshong East. Households with more cattle had buildings which were worth more than double those of households with fewer cattle assets. Neither

TABLE 3.5: VALUE OF FARM ASSETS (PULA), 1983-84

	VILLAGE		SEX OF HEAD		CATTLE ASSETS		DRAFT ACCESS		
	SHOSHONG	MAKWATE	MALE	FEMALE	36+	0-35	OWN	DEPENDENT	ALL
TOTAL ASSETS/a	11742	5733	11187	6866	16024	4803	11212	7193	9514
LIVESTOCK:									
Cattle	6225	3449	7101	2324	10080	1732	6859	3089	5264
Goats	488	154	398	332	516	267	384	356	373
Poultry	59	51	61	50	71	41	59	45	57
Donkeys	96	260	207	65	124	173	243	29	153
Other	173	66	96	0	81	43	99	5	59
TOTAL	7041	3980	7863	2771	10872	2256	7644	3524	5906
AGRICULTURAL CAPITAL:									
Plows	68	140	131	33	144	60	135	35	94
Other Equipment	353	284	204	536	155	446	233	464	328
Hand Tools	58	50	61	46	75	41	55	56	55
Receptacles	122	96	115	108	131	99	123	97	112
TOTAL	601	570	511	723	505	646	546	652	589
BUILDINGS:									
Lands Area	506	163	484	202	647	195	484	226	379
Village	3594	1020	2329	3170	4000	1706	2538	2791	2640
ASSET STRUCTURE (% OF ASSETS):									
Livestock	60	69	70	29	68	47	68	49	62
Agric. Capital	5	10	5	11	3	14	5	9	6
Buildings	34	21	25	60	29	39	27	42	32

Sources: 1984 Livestock Inventory and Farm Fixed Capital Surveys.

a. Valuation of plows, other equipment, and buildings based on farmer's assessments of current cost to obtain a replacement in the same condition. Livestock values based on average sales prices. Hand tools and receptacles valued at new replacement cost. One Pula = around $ 0.65 in 1984.

female-headed nor draft-dependent households had fewer building assets. Female-headed households had as much invested in housing as male-headed households--despite fewer cattle and lower incomes--due to inheritance, family help, and remittances.

Agricultural capital was an insignificant proportion of household assets. (Other equipment can only partially be treated as agricultural capital since it included carts and, for a few households, vehicles which had non-agricultural uses.) Households with fewer cattle did not have fewer hand tools and receptacles but did have less invested in plows (reflecting few plows). Plows are the single most important implement in arable production and investments in plows are less divisible than are those in hand tools or receptacles. A positive correlation between cattle assets and plow ownership also was found in the RIDS [Lucas, 1985].

C. LABOR ALLOCATION

This section presents an overview of household labor use by activity, month and age-gender category. Where applicable, findings are compared to those from the RIDS, recently published in Chernichovsky, Lucas and Mueller [1985], and a labor use study carried out in Shoshong in 1970 (reported in Bond [1974]). A comparison is useful since both studies are now more than ten years old. Also, the RIDS labor data were collected from 1,000 households but were based on only five days per year per household.

Household labor allocations were monitored through the MVRU Survey. There were three main objectives: (a) to assess labor requirements for crop production relative to household maintenance and other income generating activities, (b) to characterize the gender division of labor, and (c) to examine seasonality in labor use.

1. HOUSEHOLD LABOR USE

An overview of household labor use is summarized in Table 3.6. Note that the percentages in the table do not take into account leisure, school and child care--each of which would account for a lot of time if recorded [Mueller, 1985].

The single most time consuming activity was tending livestock, accounting for over a quarter of the hours worked by household members. However, taken together, household maintenance activities took more than forty percent of the total time recorded. Nearly 1,100 hours per household, or an average of three hours per day, were spent on cooking alone. Beer brewing accounted for a surprisingly small share of time, slightly more than half the amount of time spent in wage employment.

Fieldwork accounted for a only 15 percent of household members time. The most time consuming field activity was birdscaring, but birdscaring often was combined with other field activities (so separate hours were not recorded for birdscaring). The most time consuming "active" task was plowing and planting, followed by harvesting and fencing.

A short length of time usually was spent on any single activity on a given day but several different activities often were done each day. This was particularly true of household maintenance activities. Fieldwork days averaged 3.75 hours, on days fieldwork was done. The longest amount of time spent on a single activity during a day was for wage employment, an average of 7.3 hours per day on days when wage employment was done. Thus, wage employment seemingly precludes doing many other activities on the same day. This may in part explain why women can fit crop production activities into their heavy schedules,

TABLE 3.6: HOUSEHOLD LABOR USE, 1983-84

	PERSON-DAYS PER YEAR/a	PERCENT OF DAYS	HOURS PER YEAR	PERCENT OF HOURS
		(Per Household)		
FIELDWORK:	199/b	8.9	747	14.9
Clear & Destump	8		38	
Plow & Plant:	28		131	
Weed & Thin/c	18		63	
Birdscare/d	56		208	
Gather Morogo	7		13	
Other Harvest	35		116	
Fix Threshing Floor	7		21	
Thresh, Winnow & Bag	17		53	
Fence	24		105	
LIVESTOCK:	541	24.2	1362	27.2
Tend	443		1290	
Milk	98		72	
BEER:	93	4.2	261	5.2
Make	63		101	
Sell	30		160	
HOUSEHOLD MAINTENANCE:	1332	59.5	2125	42.4
Gather Firewood	154		189	
Fetch Water	545		531	
Cook	431		1097	
Wash	159		232	
Construct & Repair	43		76	
OFF-FARM:	73	3.3	513	10.3
Other Fields	10		54	
Wage Employment	63		459	
ALL	2240		5009	

Source: 1983-84 MVRU Survey; 27 households.

a. Each person working during a day counted as one person-day.

b. Numbers and percentages do not total due to rounding.

c. Includes a small number of hours spent hilling jugo beans.

d. Birdscaring time was not recorded. To account for birdscaring, 3.75 hours (the average length of an active fieldwork day) was added for each birdscaring person-day.

while men are less able to do so with their lighter schedules.

2. GENDER DIVISION OF LABOR

Table 3.7 shows the average hours per household spent on income generating and household activities by men, women, boys and girls. The table shows there was a strong gender division of labor. There was also somewhat of an age division of labor.

Men and boys were responsible for most of the livestock tending and milking labor, plowing, and field maintenance (mainly destumping and fencing). Boys actually spent more time tending livestock and plowing than did men. Boys also helped with household maintenance activities more than did men. Men, however, spent nearly twice as many hours in wage employment as did any other worker category.

Women worked more hours on more activities than either men or boys. On average, women were responsible for more than three-quarters of household maintenance time, sixty percent of weeding time, two-thirds of birdscaring time, eighty percent of harvesting and threshing time, and essentially all the time spent brewing and selling beer. Girls primarily did the same activities as women, but accounted for less than ten percent of the time recorded. Girls contributed significant amounts of labor only to gathering firewood and water, and cooking and washing. No categories of labor spent much time on construction and repair activities.

In total, females worked 37 percent more hours than did males. Since most of the activities not recorded are primarily done by females, the gap between males and females is much greater than this. On an individual basis, women worked the greatest number of hours, nearly 1,200 hours per active woman. This was more than sixty percent more

TABLE 3.7: HOUSEHOLD LABOR USE BY
AGE-GENDER CATEGORIES, 1983-84

	MEN	WOMEN	BOYS	GIRLS
		(Hours)		
FIELDWORK:				
Plow & Plant	48	20	61	1
Weed & Thin	12	40	6	6
Birdscare/a	23	143	11	34
Harvest (inc. Morogo)	11	103	4	11
Field Maintenance/b	103	32	26	2
LIVESTOCK:				
Tend	468	72	732	18
Milk	18	7	46	1
BEER:				
Make	1	98	c	1
Sell	c	159	1	c
HOUSEHOLD MAINTENANCE:				
Gather Firewood	37	77	45	29
Fetch Water	55	306	48	122
Cook	3	895	24	175
Wash	3	197	10	23
Construct & Repair	11	57	5	3
OFF-FARM:				
Wage Employment	261	154	25	19
Other Field	14	28	8	4
TOTAL:				
Per Household	1071	2435	1052	453
Per Active Person/d	729	1188	612	246

Source: 1983-84 MVRU Survey.

a. Birscaring hours calculated as in Table 3.6.

b. Includes clearing, destumping, fixing threshing floor, and fencing.

c. Less than one.

d. Active people were defined to be the number of residents in each category who were not inactive due to age or health (determined on the basis of the Household Census). The number of individuals actually contributing labor fluctuated as individuals moved in and out of the household on a temporary basis.

hours than worked per active man. The low number of hours recorded per active girl mainly reflects a failure to record hours for two of their main activities, childcare and bush gathering.

The findings on the gender division of labor generally support those from the RIDS [Mueller, 1985], the early research in Shoshong [Bond, 1974], and the NMS [CSO, 1982]. In those studies, males accounted for most of the livestock tending labor and were relatively more engaged in wage employment than females. Females on the other hand, accounted for nearly all of the household maintenance activities and a majority of the fieldwork.

3. SEASONAL PROFILE OF LABOR USE

Table 3.8 presents a monthly profile of household labor use by activity. Aside from the amount of time devoted to construction and repair, the largest monthly variation in hours worked was for fieldwork, as would ordinarily be expected. Time spent on beer brewing and wage employment also varied quite a bit over the year but generally in a counter cyclical pattern to fieldwork. As a result, total labor inputs varied less over the year than was the case for any single labor activity.

With the exception of high figures for a single month, January, there was not much difference in household maintenance labor by month. Excluding January the coefficient of variation of monthly labor inputs for household maintenance was only around fifteen percent. Mueller [1985] also concluded there was a lack of significant seasonality in labor requirements for household maintenance activities.

The MVRU Survey data showed that household maintenance labor inputs increased slightly during the cropping season. This was because the

TABLE 3.8: HOUSEHOLD LABOR USE BY MONTH, 1983-84

	FIELD-WORK	LIVE-STOCK	BEER	WAGE	WOOD/ WATER	COOK/ WASH	CONST./ REPAIR	ALL
NOVEMBER	50	102	12	44	57	94	2	361
DECEMBER	103	95	6	12	46	95	2	360
JANUARY	93	138	6	18	117	180	5	559
FEBRUARY	52/a	102	25	68	71	142	10	469
MARCH	65	159	20	62	55	114	3	478
APRIL	106	139	22	47	51	114	2	481
MAY	126	186	31	69	56	109	5	581
JUNE	108	110	19	18	52	86	5	397
JULY	38	92	24	18	43	89	2	306
AUGUST	31	87	30	30	52	100	4	333
SEPTEMBER	24	76	31	31	70	104	9	345
OCTOBER	6	75	36	44	50	103	26	339
AVERAGE	67	114	22	38	60/b	111/c	6	417
S.D.	39	35	10	20	20	27	7	93
C.V. (%)	59	31	45	53	33	24	105	22

Source: 1983-84 MVRU Survey.

a. February through June includes birdscaring days at 3.75 hours per day.

b. Without January, the mean, s.d., and c.v. for gathering firewood and fetching water are 5.5, 8.7 and 16%.

c. Without January, the mean, s.d., and c.v. for cooking and washing were 104, 15.7 and 15%.

time required for cooking, washing, gathering firewood and fetching water increased as the households split (some members going to the lands and some remaining in the village). In contrast, the RIDS showed that the time spent on household activities decreased during the cropping season. The difference may stem from the seasons monitored. The RIDS was carried out in a season with good rainfall, so cropping labor requirements may have forced a reduction in household maintenance labor.

The MVRU Survey also showed that livestock tending labor did not change much on a monthly basis but did tend to increase at the same time that fieldwork labor was the greatest. The 1985 Livestock Practices Survey confirmed that this stemmed from a need increase the intensity of herding during the cropping season in order to reduce liability for crop damage.

When examined by age-gender categories, the monthly profile of hours spent by women on household maintenance and non-cropping activities showed the least variation (a c.v. of 21 percent) while hours spent by boys showed the greatest variation (a c.v. of 39 percent). No particular month or period could be identified in which labor requirements were substantially higher than average monthly requirements. Moreover, there were no discernible seasonal trends.

4. FIELDWORK HOURS BY HOUSEHOLD TYPE

Only fieldwork hours were analyzed by household type. The analysis showed that Makwate, male-headed and draft-controlling households worked substantially more hours on fieldwork than Shoshong, female-headed, and draft-dependent households, respectively. The difference was due to the area planted, since labor inputs per hectare were similar. Shoshong households spent less time on plowing, due to use of tractors, but

Makwate households spent more time on the other field activities. The results on the relative hours of male-headed and female-headed households differ from those of the RIDS, which showed that female-headed households did more fieldwork [Lucas, 1985]. The difference in results reflects the difficulties female-headed households face in getting an adequate area plowed during drought seasons.

D. CASH REVENUES AND EXPENDITURES

This section gives an overview of cash revenue and expenditure patterns. The primary objectives are to describe: (a) the role of crop sales relative to other cash sources, (b) the importance of food grain purchases relative to other expenditures, and (c) differences in cashflow patterns by household category.

1. CASH SOURCES, 1983

A preliminary profile of cash sources was generated through the 1983 Crop Management Survey. Findings are summarized in Table 3.9. Most respondents said there were several sources of cash. A majority of households had three or more sources, from both the lands/village area and outside the village area.

Crop production played little or no role in generating cash. Few respondents said crop sales were a source of cash at all. Selling cattle was reported to be the main source of cash. Following cattle sales, selling beer, remittances, and village wage employment were ranked (in that order) as the principal sources of cash.

There were several differences in the relative importance of cash sources by village and household type. Cattle sales were particularly important for male-headed and cattle-rich households. Female-headed and cattle-poor households said they relied primarily on beer sales and

TABLE 3.9: PRIMARY INCOME SOURCE, 1983

	SELL CATTLE	SELL BEER	REMIT-TANCE	WAGE LABOR	SELL CROPS	SELL OTHER
	(Percent of Households)					
ALL	36	23	22	17	1	3
VILLAGE:						
Shoshong	46	25	18	7	0	3
Makwate	21	19	27	29	2	2
SEX OF HEAD:						
Male	51	13	12	21	0	3
Female	13	36	36	10	2	2
CATTLE ASSETS:						
0-15	8	34	28	23	2	5
16+	67	9	15	10	0	0
DRAFT ACCESS:						
Control	42	19	16	17	2	0
Depend	22	27	29	16	0	6

Source: 1983 Crop Management Survey.

remittances. Remittances were the primary source of cash for draft-dependent households. Village wage labor was the primary source of cash for more than twenty percent of male-headed, Makwate and cattle-poor households, compared to ten or less percent for their comparison households.

2. CASHFLOW ANALYSIS, 1984

Data on cash revenues and expenditures were collected during the first two years of the MVRU Survey. These data were used to: (a) verify results from the Crop Management Survey, (b) evaluate the importance of food expenditures relative to other expenditures, (c) assess relationships between cashflow patterns and household characteristics, and (d) identify seasonal cashflow patterns. Table 3.10 presents an overview of average monthly cash inflows and outflows for the MVRU

TABLE 3.10: AVERAGE MONTHLY CASHFLOWS, NOVEMBER, 1983 - JUNE, 1984 (PULA)

	VILLAGE		SEX OF HEAD		CATTLE ASSETS		
	SHOSHONG	MAKWATE	MALE	FEMALE	36+	0-35	ALL
SALES:							
Crops	1.40	0.07	0.46	1.14	0.21	0.70	0.70
Livestock	53.29	13.88	57.15	8.09	81.11	10.10	39.46
Beer	27.68	1.50	9.44	34.54	26.38	12.94	18.49
Other	2.06	0.29	1.78	0.83	2.89	0.42	1.44
MISC. REVENUES:							
Gifts and Loans	19.65	27.37	20.98	24.79	13.79	28.39	22.36
Wages	21.02	9.52	25.41	2.04	23.92	12.10	16.98
Other	5.48	0.41	4.83	1.69	6.49	1.73	3.70
TOTAL REVENUES	130.22	53.04	120.05	73.12	155.29	66.38	103.13
PURCHASES:							
Inputs	6.14	1.37	2.16	8.56	3.94	4.84	4.47
Grain and Meal	14.17	6.23	10.46	13.01	13.19	10.11	11.38
Other Food	18.37	6.46	14.91	12.92	18.34	11.27	14.19
Livestock	3.18	0.00	3.23	0.00	4.73	0.18	2.06
Household Goods	21.62	5.87	19.73	9.64	23.24	11.06	16.09
Other	1.49	0.89	1.53	0.83	1.16	1.36	1.28
MISC. EXPENDITURES:							
Gifts and Loans	0.92	0.46	0.95	0.42	0.93	0.63	0.76
Wages/a	40.08	6.18	25.72	30.14	48.54	12.77	27.36
Transport	4.74	1.42	4.04	2.74	6.07	1.81	3.57
Other	25.45	16.08	23.26	20.22	20.90	23.05	22.16
TOTAL EXPENDITURES	136.16	44.96	105.99	98.48	141.04	77.08	103.32
NET CASHFLOW	-5.94	8.08	14.06	-25.36	14.25	-10.70	-0.19

Source: 1983-84 MVRU Survey.
a. Includes fees paid for hiring traction.

Survey participants during the period November 1983 to June 1984--the cropping season.

Overall, approximately P60 was received each month via sales, and a total of just over P100 was received from all sources. Shoshong, male-headed, cattle-rich, and draft-dependent households all had substantially greater cash inflows than did their comparison household types. Female-headed households had lower cash incomes in Shoshong in the early 1970s, as well [Syson, 1972].

Livestock sales were the single largest source of cash, averaged across all households. Shoshong East, male-headed and cattle-rich households all received more cash from livestock sales than their comparison groups. Crop sales provided very little cash, as would be expected in a drought year. Beer sales were an important source of cash for several households, particularly for female-headed households in Shoshong. Cattle-rich households obtained more cash from beer sales than did cattle-poor households, because poorer households could not afford to buy the inputs required to make beer.

Gifts and loans, primarily remittances from non-resident household members, were a major source of cash for all categories of households. Gifts and loans accounted for nearly half of each month's cash inflow for Makwate and cattle-poor households. The relative contribution of remittances was less for Shoshong, male-headed and cattle-rich households than their comparison groups. Village wage cash incomes were important, particularly in Shoshong and for male-headed and richer households.

Turning to cash outflows, purchases of grain and meal, other food and households goods were substantial for all types of households.

Relatively little was spent on inputs and livestock. Inputs expenditures were higher for female-headed households, reflecting purchases of grain for making beer.

The largest single expenditure for Shoshong, male-headed, female-headed, and cattle-rich households was for traction hire, included in the wages category. Expenditures for traction hire were particularly high for male-headed and cattle-rich households, averaging P40-50 per month, but were relatively the greatest for female-headed households. Traction fees were not the largest expenditure only for cattle-poor and Makwate households, farmers who did not hire tractors.

The positive association between traction hire fees and cattle assets differs from results of the RIDS, in which cattle-rich households (who had the ability to hire) spent less on plowing services than did poorer households [Lucas, 1985]. There are two likely explanations: (a) during drought, richer households are better able to mobilize the cash required for hiring and therefore spend more on plowing services, and (b) there may be a greater preference for traction hiring in the 1980s than there was in the 1970s. The second factor is at least partially true because several traction owners chose to hire traction even after they said their animals had recovered.

The total level of expenditure in Makwate was only a third of that in Shoshong. Cattle-poor households spent just over half of that spent by the cattle-rich households. There was surprisingly little difference in expenditures by male-headed and female-headed households, despite a large difference in revenues. The net cashflow per month was negative for Shoshong, female-headed and cattle-poor households--and for all households combined. However, there was a positive net cashflow of over

P25 when one excludes traction hire fees.

An analysis of cashflows by month showed that beer revenues and expenditures on grain, other food and households goods were quite regular. Cash revenues from livestock sales were concentrated in a single month, April, when five households made large cattle sales. Remittances were high in November and October, fell to around ten Pula during most of the season and then increased to above thirty-five Pula during May and June, when it had become apparent there was going to be widespread crop failure. There was less monthly variation in expenditures than for revenues.

E. FOOD CONSUMPTION

Over the past few years, there has been a growing appreciation of the importance of a food consumption perspective in on-farm research [Frankenberger, 1985]. Since most farm production is consumed by the producing household, consumption requirements and food preferences exert a major influence on farmers' responses to suggested innovations. Farmer welfare can be improved by targeting arable farming interventions to problems areas in the diet, even if household cash income is not increased.

This section presents selected findings on the main dishes and other foods consumed in Shoshong and Makwate, the frequency of with which the major food items were consumed in 1984-85, and the primary sources of food items.

1. MAIN DISHES AND FOOD ITEMS

Farmers were asked to identify and rank their main dishes and other foods in the 1983 Crop Management Survey. The resulting rankings of main dishes and other main foods are presented in Tables 3.11 and 3.12.

TABLE 3.11: FARMER RANKINGS OF MAIN DISHES, 1983

		SHOSHONG		MAKWATE		ALL	
DISH/a	DESCRIPTION/b	RANK	POINTS/c	RANK	POINTS	RANK	POINTS
LEFATA	Sorghum or Maize & Cowpeas or Jugo Beans	3	91	1	100	1	100
BOGOBE	Sorghum & Morogo or Meat or Milk	1	100	3	43	2	81
THOPI	Sorghum & Melons	2	93	7	8	3	61
PHALECHE	Maizemeal & Morogo or Meat or Milk	4	35	6	30	4	35
MOGODU	Cowpeas & Melons	5	19	2	46	5	32
MOKGANIYANE	Sorghum Cooked With Milk	6	5	4	42	6	21
SETAMPA	Semp & Meat or Oil or Milk	7	3	5	37	7	18

Source: 1983 Crop Management Survey; 116 farmers.

a. Dish names vary within the Mahalapye area and across the country. The most common names in Shoshong and Makwate have been used.

b. There can be variations in ingredients for each dish. For example, some farmers use ground melon seeds in several dishes; other use stamped maize rather than unstamped; some use fresh milk and some sour milk, etc.

c. Farmers were asked to cite their four main dishes in order of importance. Points were given in reverse order, with four points for the most important dish, three points for the second dish, etc. Points were then transformed to a basis of 100 for the top ranked dish, to eliminate differences due to sample sizes.

TABLE 3.12: FARMER RANKINGS OF OTHER MAIN FOODS, 1983

	SHOSHONG		MAKWATE		ALL	
	RANK	POINTS/a	RANK	POINTS	RANK	POINTS
WATERMELONS	1	100	4	40	1	100
MELONS	3	83	3	52	2	96
MEAT	6	56	2	78	3	94
BEANS	8	26	1	84	4	76
MILK	2	88	7	12	5	72
SWEET REED	4	63	10	0	6	46
CUCUMBER	5	58	9	3	7	44
PUMPKINS	7	39	8	5	8	32
GREEN MAIZE	9	11	5	33	9	30
BREAD	10	7	6	32	10	26

Source: 1983 Crop Management Survey.
a. Farmers cited their four "other main foods" in order of importance. Points were calculated as described in Table 3.12.

Sorghum, maize and cowpeas were the primary constituents of most dishes. Most dishes included leafy greens (referred to by the general term "morogo"), milk or meat. Milk was consumed fresh or sour and was in some cases cooked into the grain meal while in other cases was added after cooking. Thinner porridge is generally consumed with milk for breakfast while thick porridge with a relish was consumed later in the day. The relative importance of dishes was different between Shoshong East and Makwate even though the same ingredients were used in both villages.

Watermelons and melons were viewed by most farmers as important foods. Both were consumed in large quantities beginning in March through the end of the season. Meat and beans, such as jugo beans, were important food items aside from their role in the major dishes. Milk, sweet reed (a sweet sorghum species eaten like sugar cane), cucumbers and pumpkins were highly ranked foods in Shoshong but not Makwate. The reverse held for green maize and bread.

2. FOOD CONSUMPTION FREQUENCIES

The source of information on consumption frequencies was the 1984-85 Activity Survey. Respondents were asked on a monthly basis how frequently they consumed 19 major food items. Categorical responses were recorded, distinguishing between "not at all during the month," "one to three times during the month," "two to three times a week," "four to five times a week," and "everyday or nearly everyday." Table 3.13 summarizes findings for October 1984 to September 1985. The figures refer to household-months. There were 554 observations, an average of just over 46 responding households per month.

The most frequently consumed food was maize meal, followed by sorghum meal. Sorghum meal was not consumed at all in a surprisingly high number of household-months. Bread and vegetables were eaten at least occasionally in many household-months, but green maize, rice, and cowpeas were infrequently eaten. Milk was the major source of animal protein, although it was consumed in small quantities. Chicken meat and eggs were consumed infrequently or not at all by nearly all the households.

Seasonal differences in consumption were most pronounced for animal products (except goat meat), lands morogo, and vegetables. Beef was least frequently consumed during the January to March period, at which time no beef was consumed in nearly half of the household-months. Except for the January to March period, beef was eaten more than once a week in nearly a third of the household-months. This is certainly high according to African standards. Goat milk consumption was concentrated

TABLE 3.13: FOOD CONSUMPTION FREQUENCIES, OCTOBER 1984 TO SEPTEMBER 1985

	A/a	B	C	D	E	F
	(Percent of Household-Months/b)					
GRAIN AND MEAL:						
Sorghum Meal	22	10	6	4	4	53
Maize Meal	16	9	10	5	4	56
"Stampa"	47	35	10	6	1	0
Green Maize	91	8	c	c	1	c
Bread	24	32	17	16	7	4
Rice	74	21	4	1	c	0
Cowpeas	62	25	8	3	2	c
OTHER CROPS:						
Lands Morogo	50	18	7	8	8	9
Other Morogo	90	3	1	2	1	3
Watermelons	83	5	3	3	3	4
Starchy Melons	91	3	2	1	2	1
Vegetables	45	21	11	12	7	5
ANIMAL PRODUCTS:						
Beef	29	37	9	9	9	8
Goat/Mutton	37	24	14	13	7	5
Chicken	67	30	2	1	0	1
Cow Milk	57	7	3	6	4	23
Goat Milk	44	2	1	2	1	49
Eggs	77	18	1	1	c	1

Source: 1985 Activity Survey.

a. A = not at all during month; B = one to three times during the month; C = once a week; D = two to three times a week; E = four to five times a week; F = everday or nearly every day.

b. Based on 554 responses, an average of 46 households per month.

c. Less than one.

between October and March. Cow milk was relatively more important later in the season. When cows were milked, three to four times as much milk was consumed as compared to when goat milk was consumed.

Consumption of lands morogo (leafy greens) was concentrated in the April to June period. Consumption was possible outside of that period because farmers often boil and then dry the morogo so it will keep. Winter vegetables, available in October through December, were consumed more frequently by more households than were summer vegetables.

Consumption of the major cereal grains increased only slightly as the season's harvest became available. This was because maize and sorghum meal were purchased by most households. The frequency of maize meal consumption dropped off beginning in April, just as consumption of home produced sorghum increased.

Shoshong and cattle-rich households consumed most items significantly more frequently than did Makwate and cattle-poor households, respectively (as determined by Chi-statistics from a cross tabulation analysis). There were few significant differences in consumption frequencies associated with either gender of household head or draft access.

3. SORGHUM AND MAIZE MEAL CONSUMPTION LEVELS

During the 1985 Activity Survey, respondents were asked to estimate how many kilograms of sorghum and maize meal were eaten each month by all the adults and children who ate with the household on a daily basis. The numbers of adults and children eating daily were also recorded. Just over 50 kgs. were consumed per household per month. This gave an average of approximately 7.5 kgs. per consumer each month (or about one-quarter kg. per day.) Shoshong, male-headed, draft-controlling, and cattle-rich households all consumed greater amounts of meal, both in total and per consumer (around one-third to one-half kg. more per consumer per month).

4. SOURCES OF FOOD ITEMS

In the 1985 Activity Survey, respondents also were asked to indicate which of the following was the primary source of each food item during that month: a relative, another farmer, a local trader, a trader in another village, a government feeding program, or household production.

In more than 90 percent of the household-months, traders were the primary source for maize meal, bread and rice. Green maize was obtained primarily from other farmers. Despite the dominance of sorghum in farm production, household production was the primary source of sorghum in only 31 percent of the household-months. This of course reflected the influence of the drought. With reference to other crops, melons and watermelons were obtained almost exclusively through home production or from other farmers. Most vegetables, on the other hand, were purchased from traders.

Animal products generally were obtained from home production or from other farmers. In most cases, farmers sell some beef or goat meat when they slaughter animals. Across a village, a few individuals might slaughter animals on any given day. In this way, many people can eat small quantities of meat. Farmers also often sell each other small quantities of milk. Chicken and eggs were obtained almost exclusively from home production.

A number of differences were identified in the sources of food by village and household type. Overall, Makwate households tended to rely on home production or other farmers more than did Shoshong households. Female-headed households relied less on home production of most commodities, relative to male-headed households, as did draft-dependent household relative to draft-controlling households, and cattle-rich households relative to cattle-poor households.

F. CONCLUSIONS AND IMPLICATIONS

The chapter had two main objectives. One was to provide a comprehensive profile of household circumstances, to place arable farming into a broader household and farm system context. The second was to identify significant differences in household circumstances for four distinct household categories: households in Shoshong versus households in Makwate, and male-headed versus female-headed, cattle-rich versus cattle-poor, and draft-controlling versus draft-dependent households.

The review of household circumstances showed that household and farm system resources are limited and maldistributed. A number of resource constraints were identified, any combination of which might impinge on a given household. Some households had too little labor, while others lacked implements, and still others had too little land--at least during seasons with good rainfall.

Female-headed, cattle-poor and draft-dependent households consistently had less developed land resources, fewer capital assets and fewer livestock than their counterpart household categories. These households also tended to have less cash to spend, to be more dependent on remittances, to eat less grain and meal per consumer, and to be more dependent on traders and other households for their food. Consequently, there was a "pattern of vulnerability" which extended beyond the issues of access to cattle or male labor, as identified in the RIDS [CSO, 1976] and the NMS [CSO, 1982], respectively.

Significant differences in resources also existed between households in Makwate versus households in Shoshong. Makwate households had fewer cattle and, because they were generally poorer, had less cash to spend and ate less food. At the same time, households in Makwate had as much invested in plows and hand tools, and had better developed land resources. As shown in Chapter IV, households in Makwate were more strongly oriented toward arable farming than were households in Shoshong.

The chapter showed that the allocation of existing resources to crop production was further constrained by household maintenance requirements and the allocation of resources to other production enterprises. Most of the available supply of labor was needed for households activities and livestock tending. Cash was needed to buy food and other household goods. The top priority for investment was cattle.

Because of the variety of demands on household resources, even the better off household categories (male-headed, cattle-rich, and draft-controlling households) had severe problems. These households generally had small amounts invested in agricultural implements. Most had negative cashflows, largely due to hiring traction. They were unable to eat most food items any more frequently than did the poorer households.

Finally, the chapter revealed a potential conflict between national and farmer goals for crop production. While the government would like the country to be self-sufficient in grain production, the food security of farming households depends on their ability to generate cash from non-cropping sources (including remittances). If farmers increase their investments in crop production, the potential for crop failure means that the risk of food shortfalls could actually increase [Vierich and Sheppard; 1980].

Farmers obviously are aware of the riskiness of crop production and, as a result: (a) minimize their investments in fixed capital, (b) try to rely on retained seed and household labor rather than purchased inputs, (c) invest minimal amounts of labor in plowing and planting (through broadcasting seed mixtures), (d) only invest labor in plant protection after it can be seen that there is reasonably good stand establishment and plant development, and (e) give higher priority to wage employment and the health of their cattle than they do crop production. With their current whole household risk management strategy, farmers do not lose so much in drought years and can still approach self-sufficiency in good years.

The analysis of household circumstances presented in this chapter suggests the following priorities and targeting strategies for the Ministry of Agriculture.

First, the most useful criterion for distinguishing household types would appear to be the division based on draft access. The causal relationships between draft access and cropping outcomes are clearer than are those between gender of head, cattle assets and crop production results. Moreover, the Ministry can be confident that any interventions developed for draft-dependent households will also address the needs of most poor and female-headed households.

To address the requirements of the draft access research domains, two sets of modified practices should be developed; one set assuming that control of timing and multiple tillage operations are possible, the second set assuming they are not possible. For example, technical research for the draft-dependent RD could focus on remedial stand management interventions (such as hand gap filling) and crop protection interventions, since timely and sufficient plowing cannot be assumed.

Second, because there were a variety of resource constraints besides draft access, alternatives need to be developed for each traction RD, taking into account different resource constraints. To keep targeting from getting to be too complicated, researchers should give top priority to labor constraints for both RDs. A second priority for the draft control RD would be interventions to address land shortages.

In addressing various labor and land constraints, attention should be given to production practices which do not require additional implements or cash investments. Many households cannot reasonably divert the cash needed for food into crop production and any required investment in even one new implement could easily double or more the value of capital tied up in arable production.

Third, instead of focusing just on the poor (as many consultants have recommended), the Ministry must develop technologies and programs to help all household types. Essentially all the households are poor and need help. The different household types just need different kinds of help.

Fourth, units of analysis other than the household might be appropriate for targeting some research and extension activities. For example, the Ministry should take advantage of the fact that households in Makwate use donkeys and appear to be more willing to invest in arable farming, given their resources, than do Shoshong households. As an alternative to "village targeting," the Ministry should consider targeting particular worker categories when assessing technological options. In this context, steps to alleviate the existing work burden of women should be a top priority.

Fifth, planning and policy analysis needs to pay increased attention to household circumstances. For example, the Ministry should have been able to predict that ARAP (which provided a one-time opportunity to have the government pay for up to ten hectares of plowing) would have a biased impact in favor of male-headed and cattle-rich households. Another example obtains from the food consumption analysis. Because maize, vegetables and wheat are consumed regularly, the Ministry needs to evaluate the macro economics of different approaches to increase their supply (import, Batswana commercial farmers, diversified household production).

IV. CROP SYSTEMS MANAGEMENT

This chapter presents an overview of crop systems management. Information is given on cropping objectives, major crops and varieties, draft management, traction use patterns, cropping practices, post-harvest practices, and roles in decision making. The objectives are to: (a) describe existing production and post-harvest practices, (b) characterize farmers' priorities and perceptions, and (c) synthesize implications for arable farming development priorities.

A. CROPPING OBJECTIVES

In the 1985 DUMI Study, respondents were asked to list their primary cropping objectives. Every respondent said the primary objective was to grow food for household consumption. Several respondents did not mention any other objective. The most commonly mentioned secondary objectives were to: (a) secure a diverse diet, (b) produce a surplus of sorghum to sell, (c) generate cash by growing and selling cowpeas or jugo beans, and (d) minimize the risk of complete crop failure (by growing a mixture of crops).

To verify the listing of objectives, farmers were asked to rank the relative importance of prices, consumption requirements, and seed availability in determining how much to grow of sorghum, maize, and cowpeas. All the respondents but three said that household requirements were the most important determinant of the amount of sorghum grown. Seed availability was cited second by nearly all the respondents. Only four percent said that price was one of the top two considerations. Almost sixty percent said they pay no attention to prices when making decisions about sorghum.

Household consumption requirements were the most important determinants of maize and cowpeas production as well, but prices played a relatively greater role than was the case with sorghum. For maize, seed availability was the second consideration, but nearly twenty percent of the respondents said price was the first or second consideration in growing maize. Nearly half said price was the most important determinant in growing cowpeas. Cowpeas are the closest to being a cash crop in the Central Region.

B. CROPS AND VARIETIES

To develop guidelines for on-station technical researchers, data were collected on: (a) the relative importance of different crops and varieties and (b) farmers' priorities with respect to varietal characteristics.

1. MOST IMPORTANT CROPS

Information on the number of crops grown and farmers' views on the relative importance of crops was collected in the 1983 Crop Management Survey. Respondents said they grew an average of six crops. Sorghum was the most important, followed by cowpeas, melons, watermelons, maize and jugo beans. Relative crop rankings were almost the same for farmers in Shoshong East and Makwate, and for respondents from different types of farm systems (as identified in Chapter III). Few farmers mentioned either millet or groundnuts.

Segaolane was the most important sorghum variety in 1982-83.

(Segaolane is an improved local variety of intermediate maturity.) Goromente and Moterane sorghum varieties were nearly as important and were preferred by many farmers for their taste in porridge and beer brewing. (Both are long maturing improved, local varieties.) Approximately an equal number of farmers grew Blackeye and Tswana cowpeas. (Blackeye is a dual purpose--grain and leaf--semi-erect and semi-determinant variety with intermediate maturity. Tswana cowpeas are a long maturing indeterminant, spreading variety.)

One problem encountered in asking farmers open-ended questions about which crops are grown is their tendency to ignore minor crops. To generate a complete profile of crops grown, farmers were asked in 1985 to indicate which of a specified list of crops they had planted. Sorghum, melons and cowpeas were grown by more than 90 percent of households, followed by maize (75%) and sweet reed (71%). No other crops were grown by more than thirty percent of the households. Jugo beans and tepary beans were grown by more than twenty percent but millet, sunflower, mung beans and groundnuts were grown by only a few farmers.

2. DESIRED VARIETAL CHARACTERISTICS FOR SORGHUM

Farmers were asked during the 1985 DUMI Study to identify the most important sorghum varietal characteristics and to say what they like and dislike about the current main varieties. The most commonly cited characteristics were early maturity, large seed size, and heat and drought tolerance. Lesser important criteria were palatability and color, ease of threshing and stamping, disease and bird resistance, and good storing qualities.

Nine major sorghum varieties were identified. Moterane, Goromente and Marupantse were the main varieties grown in the area until the government introduced Segaolane (from another part of the country). Most respondents said the three traditional varieties taste good, thresh and stamp well, store well, and are heat and drought resistant. Many said they yield well and have big heads, particularly Goromente. The biggest complaint against them was the length of time to maturity. The main advantage of Segaolane is its relatively quick maturity. More respondents than not said it is heat resistant and tastes good. Some complained that Segaolane is susceptible to weevils when in store. A few said they did not like its taste nor the way it cooks. Kromo, Raigop, and Kanye were grown by only a small proportion of farmers. Comments about these varieties generally were favorable, noting their quick maturity, heat tolerance, and relatively big seeds.

Most criticisms were reserved for the Red Swazi variety, provided by the government through the Drought Relief program. Many respondents said it is not heat tolerant and is susceptible to pests. Several said the porridge is tasteless. Others noted that the grain take a long time to ripen, leaving it susceptible to bird attacks. 8-D, another quick maturing variety introduced by the government, was criticized for being susceptible to heat.

C. DRAFT MANAGEMENT

A distinctive feature of crop production in Botswana is the importance of animal and tractor traction. While the introduction of animal traction is a major issue in many African countries, animal draft has been used in the Botswana since the beginning of the century [Pingali, Bigot, Binswanger, 1987]. Control of traction resources is strongly associated with control of other resources (Chapter III), crop system performance, and the viability of recommended practices (Chapter V).

To understand factors affecting access to and use of traction resources, an investigation was carried out on draft management in 1983. Two main issues were investigated: (a) how are owned traction animals managed, and (b) what are the rights and obligations associated with inter-household drafts arrangements.

1. MANAGEMENT OF OWNED TRACTION

Data were collected on: (a) how many animals are used, (b) how long animals are used, (c) whether animals are fit to start plowing when the rains begin, (d) the length of time spent training animals, and (e) plowing for others. Each of these issues affects the timing and amount of plowing.

Half of the households using cattle plowed with eight or ten animals and the other half used six. Most of the households plowing with donkeys used six animals but a third only used four animals. No households using cattle plowed with just four animals.

There was no consensus on how long animals should be used. The most common response for cattle users was three to four years. Cattle users usually took into consideration when animals were the proper age to be sold for beef. Donkey users were not concerned about the issue since selling donkeys was not anticipated.

As of the 1982-83 season, most respondents said their animals usually were strong enough in to begin plowing in October. Half of the respondents, however, qualified their answer by saying it depended on whether rains had been good during the prior season. These views directly affect the viability of forage crops.

Approximately a third of the respondents began plowing after no or a single day of training. Another third said only two to three days were required for training. In general, training did not delay the start of plowing.

Just over half the households had plowed for relatives but only a third had ever hired out. Respondents who had not plowed for relatives usually said their relatives had their own draft or that they had never been asked to plow. Of the households which had never plowed for hire, most said they felt plowing for hire would not allow them to finish their own fields. A quarter said they had never been asked and others expressed concern about overworking their animals. In general, farmers did not like to plow for others but did so out of a sense of obligation.

2. INTER-HOUSEHOLD DRAFT ARRANGEMENTS

Control over traction resources affects the ability to do timely plowing and multiple tillage operations [FAO, 1974; Oland, Alverson, Cummings, 1980]. But control of traction is not a simple issue in Botswana. There are several ways of getting access to traction, each associated with different rights and obligations [Curtis, 1972; Alverson, 1978; Gulbrandsen; 1980]. The networks of draft arrangements which link households, therefore, need to be considered when evaluating cropping outcomes and production recommendations [Behnke and Kerven, 1983].

Despite the importance of draft arrangements, there have been few systematic studies which address the rights and obligations affecting the control of timing. Most of the available information is based on: (a) ethnographic descriptions which discuss resource exchange patterns in general terms or (b) case studies focused on the specific networks of specific households (for example, Behnke and Kerven [1983]). To complement the existing studies, information was collected in 1983 on three key draft arrangements: (a) borrowing, (b) hiring, and (e) cooperative plowing.

a. Use of Managed or Borrowed Traction

Of the entire sample, only seven households used borrowed or managed traction. Out of this limited sample, traction animals were obtained from both relatives and neighbors, so loaning was not restricted to family. In only one case was a gift given to or work done for the household which provided traction. In four cases, no time was specified as to when the animals were to be returned. In the remaining cases, the loans were at least for the entire plowing period.

In six of seven cases, the person borrowing traction was free to use that traction for hiring out. Respondents from five of those households said they would not give any money to the traction owner if they did hire out. In fact, in only one case did the traction owner retain any say on how the traction was to be used. Even if an animal died while under the control of a borrower, no compensation was due the owner. In most cases, however, the carcass would either be given to or shared with the owner.

b. Hiring Traction

Thirty-nine households had hired traction but only six households had hired out traction. In twelve cases donkeys had been hired. Cattle had been hired in another 12 cases. In the remaining cases tractors had been hired. Tractors hire rates were more than double cattle hire rates and three to four times higher than donkey hire rates.

In almost forty percent of the cases, the people involved in the hiring arrangement were relatives. Nevertheless, the hiring of a relative instead of a neighbor did not give the hirer any additional rights. For example, in nearly all cases a complete payment was made at the time of plowing, the person hiring out also provided the plow, and the person hiring in provided food.

The time of plowing generally was scheduled by the person who hired, usually in relation to the following set of rains. However, plowing often was not done when scheduled. If there was too long of a delay and soil moisture became insufficient, the person hiring did have the right to say that the plowing should be delayed until another rain. This was an important decision since replowing was rarely done if germination failed after a first plowing. Replowing was more frequently done if there was substantial early weed development, demonstrating that the first plowing had been poorly done.

c. Cooperative Plowing

Two-thirds of cooperative arrangements were with relatives. In most cases, the motivation for the relationship was to gain access to plowing resources, either labor or traction. In ten cases, however, the motive was to help friends or relatives. Most of time, the provider of labor initiated the cooperative arrangement. Nevertheless, most respondents said that both cooperators benefited equally from the arrangement.

Both providers of labor and providers of traction agreed that the household providing traction had the major say over the timing of plowing, although some households said this was a joint decision. Both partners usually were involved in the decision as to whether soil moisture was adequate on the day plowing was scheduled.

There generally was a fixed amount of time spent on each field before shifting. Most frequently reported was three days or a week. The main factors considered when determining how much plowing was done each day were soil moisture, the condition of animals and the starting time. All households reported that replowing would be done if there was poor germination. Essentially all households also reported that if the reciprocal plowing was not completed in one season due to a lack of rain, the obligation would be carried out the following season.

D. TRACTION USE PATTERNS

Two traction use pattern issues were investigated: (a) trends in traction use and (b) the timing of plowing during the season and vis-a-vis rains.

1. TRENDS IN TRACTION USE

Data on traction use patterns were collected in the 1983 Crop Management Survey. To evaluate trends in traction use, many of the same households were contacted again in 1985 DUMI Study. A summary of findings is presented in Table 4.1.

Between 1980 and 1985, a majority of households in Makwate only used donkeys and more than ninety percent did some plowing with donkeys. In 1982-83 more than eighty percent considered donkeys to be their primary traction but this fell to under seventy percent by 1984-85. This was due to a forced substitution of tractors for donkeys, since many donkey had died or were in too poor condition to plow. Tractors were almost unknown in Makwate in 1982-83 but were the primary traction of twenty percent of the interviewed households in 1984-85.

Cattle were the main type of traction in Shoshong East in 1982-83 but there was a dramatic increase in the use of tractors between the

TABLE 4.1: TRACTION USED AND DRAFT ACCESS, 1982-83 AND 1984-85

	VILLAGE		SEX HEAD		CATTLE		
	SHOS.	MAKW.	MALE	FEMALE	0-15	16+	ALL
	(Percent of Households)						
TYPES OF TRACTION; 1982-83:							
Donkeys	7	77	30	45	52	18	36
Cattle	46	17	38	28	33	35	34
Tractors	34	0	25	13	11	29	20
Tractors & Cattle	13	0	3	15	3	13	16
Tractors & Donkeys	0	2	1	0	0	2	2
Cattle & Donkeys	0	4	3	0	0	4	4
TYPES OF TRACTION; 1982-85:							
Donkeys	11	54	43	21	44	10	31
Cattle	14	8	4	17	6	20	12
Tractors	39	0	22	21	16	30	21
Tractors & Cattle	32	0	13	21	13	25	17
Tractors & Donkeys	4	8	4	7	9	0	6
Cattle & Donkeys	0	17	9	7	6	10	8
All Three Types	0	13	4	7	6	0	6
PRIMARY TRACTION; 1982-83:							
Donkeys	4	83	37	38	51	22	37
Cattle	51	17	38	35	34	40	37
Tractors	44	0	25	26	15	38	26
PRIMARY TRACTION; 1984-85:							
Donkeys	11	67	52	24	50	15	37
Cattle	29	13	13	28	13	35	21
Tractors	61	21	35	48	37	50	42
PRIMARY ACCESS; 1982-83:							
Own, Borrow	51	78	72	48	55	70	62
Hire	39	16	17	47	31	26	29
Coop Arrange.	10	6	11	5	14	4	9
PRIMARY ACCESS; 1984-85:							
Own, Borrow	29	54	65	21	28	60	40
Hire	68	33	26	72	59	40	52
Coop Arrange.	4	13	9	7	13	0	8

Soures: 1983 Crop Management Survey.
1985 DUMI Study.

1982-83 and 1984-85 seasons. In Shoshong East, less than thirty percent of the households did not use tractors between 1980 and 1985 and by 1984-85 more than sixty percent of households considered tractors to be their primary traction. The proportion of Shoshong households which considered donkeys to be their primary traction (while still small) almost tripled between the 1982-83 and 1984-85 seasons. The use of donkeys as a supplementary source of traction increased even more dramatically.

In the 1982-83 season, tractor use was equally common for male-headed versus female-headed households. Fortmann [1981] also reported no significant difference in the use of tractors by male-headed versus female-headed households. By the 1984-85 season, however, nearly half the female-headed households primarily relied on tractors, compared to just over one-third of the male-headed households. In both the 1982-83 and 1984-85 seasons, a larger proportion of cattle-rich households used tractors than did cattle-poor households. The share of household using tractors increased for both household types between 1982 and 1985.

The shift in traction use was reflected in the primary means of draft access. In 1982-83, two-thirds of the households primarily relied on owned traction. By 1984-85, less than half the households used any owned traction and nearly two-thirds hired at least some of their traction. A majority of farmers considered hiring to be their primary form of draft access.

The primary impetus for the shift in traction use and draft access was the drought. Many farmers reported that their draft animals were unfit for plowing. While draft dependency increased during the drought, it is notable that so many farmers were able to continue plowing by hiring traction. During prior droughts in Botswana, many farmers simply stopped plowing. The ability of farmers to hire traction was facilitated through government payments for plowing under two drought relief programs.

The trend toward traction hire may not be completely reversed once the rains recover. Many farmers now hiring tractors express little interest in returning to animal traction. In addition, the continuing migration of younger household members to larger villages and towns may soon leave too little labor for many households to plow with animals. It can also be expected that some households now hiring tractors will shift to donkeys after the drought, rather than go back to cattle, since several households have lost all or most of their cattle. Donkeys sell for one-third to one-quarter the price of oxen, and fewer are used in plowing.

2. TIMING OF PLOWING

Two notions of timing are important determinants of cropping outcomes: when plowing is done during the season and the timing of plowing vis-a-vis any given planting rain (usually a rainfall of at least 15-20 mm). November and December plantings have the highest probability of success (although this may not hold in any given season). Consequently, early planting has been a long-standing extension recommendation. The Ministry also recommends planting as soon as possible after it rains, to ensure there is adequate soil moisture for germination (without having to rely on a post-planting rain).

A profile of the starting and ending months for plowing in the 1982-83 and 1984-85 seasons, and "usually" is given in Table 4.2.

TABLE 4.2: TIMING OF PLOWING; 1982-83 and 1984-85

	START PLOWING			END PLOWING		
	BEFORE DECEM.	DECEM.	AFTER DECEM.	BEFORE JAN.	JAN.	AFTER JAN.
	(Percent of Households)					
USUALLY						
VILLAGE:/ab						
Shoshong East	57	24	19	24	41	35
Makwate	90	7	3	21	69	10
DRAFT ACCESS:/a						
Own, Manage	89	8	3	28	56	17
Hire, Coop	57	14	28	14	62	24
SEX HOUSEHOLD HEAD:						
Male	77	15	8	2	46	26
Female	62	19	19	15	63	22
ALL	72	17	12	23	53	24
1982-83 SEASON						
VILLAGE:/b						
Shoshong East	37	23	40	37	40	23
Makwate	59	26	15	72	20	8
DRAFT ACCESS:/a						
Own, Manage	61	22	17	57	31	12
Hire, Coop	24	29	47	45	30	25
SEX HOUSEHOLD HEAD:						
Male	56	18	26	45	36	19
Female	35	35	30	64	23	17
ALL	47	25	28	53	31	16
1984-85 SEASON						
VILLAGE:/a						
Shoshong East	0	35	65	23	50	27
Makwate	29	42	29	38	42	20
DRAFT ACCESS:						
Own, Manage	14	48	38	33	38	29
Hire, Coop	13	30	57	27	50	23
SEX HOUSEHOLD HEAD:						
Male	17	39	44	35	39	26
Female	11	36	53	25	50	25
ALL	14	37	49	29	45	26

Sources: 1983 Crop Management Survey and 1985 DUMI Study.

a. Proportions of households beginning plowing in each period is significantly different at .95 confidence level.

b. Proportions of households ending plowing in each period is significantly different at .95 confidence level.

Makwate households tend to start and end their plowing before those in Shoshong East. These is true regardless of whether one refers to farmers' perceptions of usual starting times or to actual times in 1982-83 and 1984-85. Draft-dependent households consistently start later than draft-controlling households. The same relationship between draft control and the start of plowing was noted by the FAO [1974], Sheppard and Clement-Jones [1979], Vierich and Sheppard [1980], and in others studies. Since female-headed households are more dependent on hired traction than male-headed households (Table 4.1), they too tend to start their plowing later. Bond [1974] similarly found that unmarried women and widows tend to start later than married couples.

Two managerial issues relating to the timing of plowing during the season were investigated in the DUMI Study. The first was on which set of rains does plowing normally start. Most respondents said they generally wait until the third set of rains. The reasons for waiting included the following: (a) to avoid the extreme heat and drought spells which often follow the first couple of rains, (b) draft animals often are in poor condition early in the season, (c) there is better weed control if weed seeds are allowed to germinate before plowing, (d) to avoid crop damage from livestock, (e) cash to hire traction or buy seeds often does not arrive through remittances until later, and (f) to there tend to be multiple rains during late December and early January.

Some additional reasons for starting late were identified by Hertel [1977] and Gulbrandsen [1980], including: (a) important village celebrations take place in early spring, (b) school children and mine laborers cannot help until Christmas vacation, (c) draft animals cannot be hired until owners finish plowing for themselves, and (d) higher bird damage on early planted crops.

The second seasonal timing issue addressed was: How late in the season will plowing be done? As noted in the Appendix, night temperatures turn too cold for sorghum maturation by April or May. When there are infrequent rains during the early part of the season, farmers often have to decide whether to continue planting sorghum later into the season than ordinarily desired. When asked in 1983, 55 of the respondents said they would continue into February, including nearly thirty percent who said they would continue into early March. Early January is about the latest that technical researchers are willing to plant their trials.

Data on the timing of plowing vis-a-vis planting rains were collected in the MVRU Survey and through technical plot monitoring. Plot monitoring data from both 1983-84 and 1984-85 showed that households controlling access to draft plowed more area and a greater proportion of their area on good to excellent soil moisture than did hiring households. More than half of the area planted by hiring households in 1983-84 was planted on drying or insufficient soil moisture. Data from the 1984-85 MVRU Survey (all households controlling traction) showed, in contrast, that 62 percent of the area was plowed within two days of when plowing could begin after a rain. Only ten percent of the area was plowed more than four days after plowing started on each rain.

One key managerial issue relating to the timing of plowing vis-a-vis rains was investigated in the DUMI Study: Do farmers consciously plow and plant on drying soil moisture conditions? Nearly all experiment station trials are put-in immediately following rains, on excellent soil moisture but farmers often continue plowing beyond the point at which soil moisture is adequate for germination and emergence.

Nearly all the respondents reported that they do plant on drying conditions. Most of those who plow and plant on drying conditions said that they believe the seed can remain in the ground for long periods, if it is dry, and will germinate when there is a following rain. Several farmers said that whether planting is done on marginal soil moisture depends on the month. Early in the season, they use only good moisture days. Later in the season, when the number of potential plowing opportunities has decreased, they plow on less optimal days. The few respondents who said they do not plow and plant on drying conditions expressed concern over their draft animals, not concern over poor emergence percentages.

E. CROPPING PRACTICES

National data show that most farmers in the Central Region broadcast plant sorghum-dominated seed mixtures, incorporate the seed using a mouldboard plow, do not apply fertilizer, and only do a single weeding (see the Appendix). One objective in conducting research on cropping practices was to verify that practices in Shoshong and Makwate were typical for the Central Region. Three additional objectives were to: (a) characterize "traditional" farming practices, (b) determine whether the use of recommended practices was associated with household (or farm system) types, and (c) have farmers assess the major recommended practices.

1. VARIATIONS IN TRADITIONAL PRACTICES

In the 1983 Crop Management Survey, farmers were asked about their standard plowing and planting practices. No single set of traditional practices could be identified. For example, just over half the households planted some crops in sole stands, even though nearly all households planted mostly crop mixtures (as national data indicate). Fifty percent planted the same crops in the same places every year but the others changed crop locations. Over forty percent purposively rotated crops. Just over half changed the direction of plowing each year, while the others always plowed in the same direction. Finally, just under half planted particular parts of their field first each year, while the others started at different places.

There were substantial differences in the plowing and planting practices used in Makwate and Shoshong East. In general, Makwate households used more "progressive" practices. For example, more Makwate households rotated their crops and took into account field and crop/variety characteristics when deciding what to plant, when and where. The use of the different plowing and planting practices was not associated with the sex of household head, draft control or cattle assets.

To characterize the "progressive" traditional practices, participants in the 1983 Crop Management Survey were asked: (a) which crops are sole planted, (b) which crops are rotated and why, (c) which parts of the field are planted first each year, and (d) which crop are planted first and why.

Sorghum was sole planted by more households than any other crop but the proportion of sorghum area which was sole planted was quite small. Cowpeas, maize and jugo beans were frequently planted sole and for each a relatively large proportion of the area planted was sole planted. (This finding stimulated an interest in exploring the advantages of planting secondary crops in sole stands; see Chapter VI).

The most common crop rotation was sorghum and cowpeas, followed by sorghum and maize, maize and cowpeas, sorghum and jugo beans, and maize and jugo beans, in that order. A total of 16 different crop rotations were identified, but sorghum and cowpeas accounted for nearly 40 percent of the responses.

The main reason for changing crop locations in the field was to increase soil fertility (due to nitrogen fixation by cowpeas). Twenty percent shifted their crops in order to control striga on sorghum and witchweed on cowpeas. Most of the others shifted their crops in order find out where different crops grow the best.

The most common strategy, when selecting where to start plowing, was to plow on the sandier parts of the field. Several respondents said that the sandier soils are easier to plow when their traction animals are still weak. Other respondents rightly noted that sandier soils moisten to plow depth sooner than do clayey soils. Four other types of areas were plowed first during the season: heavily weeded areas (to control weed development), well destumped parts of the field (since plowing is easier), parts nearer the compound (easier to protect from livestock), and parts nearer other fields (less bird damage).

Most farmers naturally said they plant long maturing crops first each season, including jugo beans, Goromente and Moterane sorghum, Tswana cowpeas, and watermelons. These crops also tend to be tolerant of the high December and January temperatures. Quick maturing varieties of sorghum, cowpeas, and maize were planted later in the season. Late plantings were made in order to escape mid-season droughts and rain damage (either lodging or various grain molds). A small number of respondents said they plant some maize and quick maturing cowpeas early in the season, to provide "green mealies" (corn on the cob) and morogo (spinach) for consumption in March and April.

In the 1984 Cowpea Baseline Survey and the 1985 DUMI Study, further attempts were made to characterize traditional practices. The Cowpea Survey revealed that farmers do not have any strategy for dealing with insect pests, although pests such as grasshoppers can quickly destroy cowpeas plots. To control disease problems, they select seed only from the healthy plants. Several strategies were followed in picking cowpea leaves: some farmers completely defoliated plants, others removed selected vines, and others periodically took a few leaves from each of several plants. Only a few waited until after the grain harvest to strip leaves. Reflecting the diversity of defoliation practices, there was no consensus as to whether defoliation reduced grain yield.

In the 1985 DUMI Study, farmers were asked whether they take into account soil moisture when deciding what to plant (because different crops and varieties have differing moisture requirements for proper germination). Essentially all the farmers were aware of relative soil moisture requirements, and took them into account. For example, all the farmers said they try to plant maize only when there is good moisture. Jugo beans and groundnuts also were planted on good moisture, if possible. Most farmers said that their traditional varieties of sorghum and cowpeas could be planted into drying soils.

The DUMI Study showed there was diversity in post-planting practices as well. While a majority did not thin or replant, a number of respondents did do these operations when needed. The farmers who did not thin gave a number of reasons for not doing so, most of which implied they thought thinning was not beneficial. Most of the farmers who thinned said they thin when the soil is moist, so the remaining plants do not become desiccated. The farmers who replanted generally said they wait one or two rains before replanting, since there can be substantial delayed emergence if the initial planting was done on poor soil moisture. Some farmers replanted by replowing, others used metal harrows, and still others dragged branches over the plot in order to incorporate the seed. Hand replanting generally was done with a hand hoe.

In summary, there was substantial heterogeneity in "traditional" plowing and planting practices, and post-planting practices. Some practices seem to be more progressive, based on basic agronomic principles and observation. Few of the actual benefits associated with the use of "progressive" traditional strategies and practices have been investigated.

2. USE OF RECOMMENDED PRACTICES

There is not a single recommended sorghum package in Botswana. Instead a number of extension recommendations have been developed and promoted over the past forty years. A summary of the main current recommendations and their use by households participating in the 1983 Crop Management survey is presented in Table 4.3.

Early planting was the most commonly used recommendation, followed by multiple weeding and hand planting. These practices actually are "progressive traditional" practices which the extension service now recommends to all farmers.

Few farmers used any of the "modern" practices recommended by DAFS, including row planting, harrowing, third furrow hand planting,

TABLE 4.3: USE OF RECOMMENDED CROPPING PRACTICES, 1983

	VILLAGE		SEX HEAD		CATTLE		DRAFT ACCESS		
	SHOS.	MAKW.	MALE	FEMALE	0-15	16+	CONTROL	DEPEND.	ALL
	(Percent of Households)								
EARLY PLOW-PLANT	24	63	52	21	38	42	60	14	40
MULTIPLE WEEDINGS	6	67	29	34	38	24	35	25	31
HAND PLANT	19	38	23	32	33	20	25	29	27
USE HARROW	12	17	22	2	11	16	22	4	14
ROW PLANT	6	15	13	4	8	11	14	4	10
EARLY PLOW W/O PLANT	12	2	14	0	2	16	14	2	9
USE FALLOWING	7	4	7	4	7	5	3	10	6
3RD FURROW HAND PLANT	0	10	6	2	5	4	8	0	4
STORED CROP RESIDUE	3	0	3	0	2	2	2	2	2
USED CORRAL MANURE	0	4	1	2	2	2	3	0	2

Source: 1983 Crop Management Survey.

fallowing, cutting crop residues, or incorporating corral manure. Only 14 percent of the households had ever used a harrow and only ten percent had ever tried row planting. Even fewer households had ever tried third furrow hand planting, fallowing, cutting and storing crop residues, or incorporating corral manure. Aside from row planting and harrowing, few respondents even knew a user of the "modern" practices and, therefore, had little or no basis for evaluating the relevance of the extension recommendations.

3. PERCEPTIONS OF RECOMMENDED PRACTICES

In order to determine why farmers were not using the extension recommendations, participants in the 1983 survey were asked whether a practice would increase production, if used. Respondents who did not use recommendations were asked why. Summary findings are presented in Table 4.4.

The respondents expressed the greatest confidence in row planting and early planting. Very few farmers doubted that either practice would increase their crop production. Lack of resources, particularly control over traction and implements, was the main reason why more farmers had not tried row planting. Few farmers said they were deterred by the extra expense. Some respondents said they could not early plant because of the risk of cattle damage.

The next most positively perceived recommendations were multiple weeding, incorporation of corral manure and harrowing. Half the respondents said that multiple weeding would increase production but most of them also said they did not have enough labor to do more than a single weeding. Also, nearly a third said multiple weeding would not help, more than was the case for any other practice. More than forty

TABLE 4.4: FARMERS' PERCEPTIONS OF RECOMMENDED PRACTICES, 1983

	ROW PLANT	EARLY PLANT	HARROW	HAND FURROW PLANT	HAND HOE PLANT	MULT-IPLE WEED	CORRAL MANUR-ING	FALLOW IN ROTATION
	PERCENT OF FARMERS							
WOULD INCREASE PRODUCTION:								
Yes	60	70	36	16	28	51	41	23
No	3	3	7	9	17	5	2	6
Don°t Know	38	27	57	75	54	44	58	71
WHY NOT USE:	PERCENT OF RESPONSES/a							
Lack Trac. & Implem./b	30	44	23	11				
Lack Implements	30	4	33					
Lack Labor	10	17	9	10	32	46	14	2
Lack Knowledge	17	19	26	75	49	26	47	76
No Interest/No Benefit	5	5	5	2	19	28	11	21
Stumps	3		3					
Extra Expense	2	4	2	1				
Cattle Damage		5						
Unreliable Rains	3	3						
Cannot Transport							16	
No Manure							5	
More Weeds							7	

Source: 1983 Crop Management Survey.
a. The number of responses ranged from 72 to 116.
b. Farmers lacking traction usually lacked row planters and harrows and so are included in this combined category.

percent of the farmers said they thought that incorporating corral manure would increase production. Again, however, several resource constraints were identified, including too little labor, lack of manure, and no transport. Some farmers said that manuring causes more weeds. More than a third of the respondents felt that harrowing (as a planting method) would help. Lack of traction and a harrow were the main constraints.

Farmers felt least certain about the benefits from hand hoe planting, fallowing and hand furrow planting. The latter two were essentially unknown in the area. Less than thirty percent of the farmers said than hand planting would increase production and an even larger share said they did not have the labor needed to do hand planting. Many respondents said they just did not like the idea of hand planting or the idea of fallowing. Fallowing was seen as waste of land.

F. POST-HARVEST PRACTICES

It was only possible to investigate post-harvest issues by asking farmers about their normal practices, since most farmers harvested little or no grain. Two issues were addressed in the 1983 Crop Management survey: (a) where is seed selected for future plantings and (b) how are the food grains stored. In 1984, participants in the the Cowpea Baseline Survey were ask about their use of crop residues.

1. SEED SELECTION

More that two-thirds of the respondents in 1983 said that they selected seed at the threshing floor before threshing takes place. Only 23 percent said that they selected seed in the field, while ten percent said they selected seed after threshing. A greater proportion of respondents from Makwate and draft-controlling households than Shoshong and draft-dependent households, respectively, said they selected seed in the field where plant characteristics could be considered.

Most seed selection was based on head characteristics. Half the respondents said that they select fully mature heads without any smut. More than forty percent said they pick the heads having large seeds. In essence, the respondents merely looked for the best heads among the ones they harvested for each of the varieties grown. Plant characteristics were not taken into account, nor were interactions between micro-environments and head development.

2. STORAGE

As can be seen in Table 4.5, nearly all households stored their grain for both food and seed in bags. Traditional storage methods, such as mud cribs and reed baskets, have disappeared throughout much of Botswana [Hamilton, 1975].

TABLE 4.5: STORAGE PRACTICES, 1983

	SORGHUM		MAIZE		COWPEAS	
	FOOD	SEED	FOOD	SEED	FOOD	SEED
	(Percent of Househods)					
CONTAINER:						
Bags	98	94	98	96	97	89
SEED PROTECTION:						
Nothing	52	44	53	49	45	40
Ash	43	47	42	43	48	48
Chemicals	5	9	5	8	7	12

Source: 1983 Crop Management Survey.

Research from around Africa generally has shown that bag storage is as good or better than other methods [Eicher and Baker, 1982]. Hamilton [1975], however, observed high insect pest infestation in bag storage in a study in the S.E. Kweneng District.

In 1983, nearly half the respondents used nothing to protect their seed grain, while most of the rest used burnt manure or wood ash. Less than ten percent of the households used seed protection chemicals. Similar proportions were noted by Hamilton.

3. CROP RESIDUE USE

One of the main recommendations of the Ministry is to cut and store crop residues, to be fed to draft animals (or cows) during the dry winter. The 1983 Crop Management Survey showed, however, that few farmers cut, remove and store crop residues - or feel they have the labor resources to do so. In 1984, as a follow-on, farmers' field residue management strategies were investigated. Results are summarized in Table 4.6.

There was little or no management involved in the use of crop residues. Which animals grazed residues was determined by which animals were in the vicinity of the field at the end of the season. As a result, 80 percent of the respondents reported that non-household animals grazed their crop residues. In few cases did the owners of non-household animals pay when the residues belonging to other households were grazed.

Most residues were grazed immediately after the harvest and few respondents reported that it would be possible to prevent grazing after the harvest was complete. Only one household reported that residues had ever been removed and stored for later feeding. At present, the

TABLE 4.6: USE OF COWPEA RESIDUES, 1984

	SHOSHONG	MAKWATE	ALL
	(Percent of Households)		
OWN ANIMALS GRAZE RESIDUES:			
Yes	60	74	65
No	33	5	22
Do Not Own Animals	7	21	12
IF ANIMALS GRAZE, WHICH ANIMALS:			
Large and Small Stock	32	46	38
Cattle	47	0	28
Donkeys	5	38	19
Goats	16	0	9
Cattle and Donkeys	0	15	6
CONTROL OF ACCESS TO GRAZING:			
Non-Household Animals Graze	87	68	80
Grazing Immediately Follows Harvest	100	37	76
Farmer Could Prevent Grazing	13	32	20
Owners of Non-Household Animals Pay	12	8	10
Farmer Selects Animals	5	0	3
EVER HAVE REMOVED STOVER	3	0	2

Source: 1984 Cowpea Baseline Survey.

dominant managerial strategy relating to use of crop residues is to let the livestock have one last, big feast before they have to cope with the shortage of graze and browse during the dry season.

G. PERCEPTIONS OF PROBLEMS

To determine farmers' priorities, participants in the 1983 Crop Management Survey were asked to identify their top three crop production problems. Follow-up questions on problems were asked in 1985. This section summarizes findings, and then notes the problems farmers have identified in five other studies.

1. SHOSHONG AND MAKWATE FARMERS

In 1983, the most common problem was livestock damage (and implicitly a problem of inadequate fencing), cited by more than a third of the respondents. The other major problems cited were (in order of frequency): lack of draft power, lack of cash (for hiring traction and buying seed), lack of implements, labor shortages and a shortage of water at the lands. Even though the question was open-ended, all the the main responses referred to resource constraints--not husbandry problems.

The 1983 survey participants also were asked to rank the relative importance of their resource constraints. Findings are summarized in Table 4.7 for different household types.

TABLE 4.7: FARMERS' RANKINGS OF RESOURCE CONSTRAINTS, 1983

	CASH/a	LABOR	FENCING	EQUIP.	TRACTION ANIMALS/b	LAND
	(Percent of Responses/c)					
VILLAGE:						
Shoshong	31	24	31	3	6	4
Makwate	53	20	7	16	5	4
SEX OF HEAD:						
Male	29	28	25	9	5	5
Female	52	15	17	6	6	2
CATTLE ASSETS:						
0-15	55	15	12	10	7	2
16+	20	31	33	6	4	6
DRAFT ACCESS:						
Control	33	26	25	7	3	7
Dependent	46	18	18	10	8	0
ALL	39	23	22	8	5	4

Source: 1983 Crop Management Survey.
a. Lack of cash for seed, transport to traction hiring.
b. Too few or weak traction animals.
c. Respondents identified their top two constraints out of the list of six. Percentages are based on the number of responses received.

Overall, lack of cash for obtaining needed inputs was the main resource constraint. This was followed by too little labor at times and inadequate fencing. Respondents from female-headed and cattle-poor households emphasized the problem of no cash, while male-headed, draft-controlling and cattle-rich households reported that labor shortages and inadequate fencing were equally important.

In the 1985 DUMI Study, respondents were asked to identify from a list which problems had reduced crop production that season. Nearly all, of course, cited the drought. In addition, more than 60 percent of the respondents had severe insect pest attacks, 55 percent had poor plant establishment, and 43 percent lost crops to livestock. Too many weeds, crop diseases and labor shortages were cited by relatively few farmers, reflecting the impact of the drought. When respondents were asked to identify their major insect pests, the most frequently identified pests in Shoshong were the Corn Cricket, CMR Beetle and the American Bollworm. In Makwate, the main pests were the Elegant grasshopper, American Bollworm, and Corn Cricket.

2. FINDINGS FROM OTHER STUDIES

Additional information on farmers' views of their problems is available from the FAO [1974], Bond [1974], Alverson [1979], Fortmann [1981] and Gaosegelwe, et al. [1983]. The FAO study covered the whole country. Bond's results are from the Southern and Gaborone Agricultural Regions. Alverson's survey was of a small number of farmers in the Gaborone Region. Fortmann's survey covered 355 households in 12 villages from the Francistown, Central, Gaborone and Southern Regions. Gaosegelwe, et al. interviewed farmers in the Ngamiland West District of the Maun Region.

In the FAO study, respondents were asked what factors kept them from plowing more land than they did. The responses in order of importance were: drought, lack of seed, draft power not available, lack of implements, labor shortages, oxen too weak, and no food at the lands.

Bond asked about arable farming problems, and presented separate results based on gender and marital status. For the population as a whole, the main problems in order of importance were: difficulty in hiring traction, labor shortages, weeds and birds (one category), and animal damage. The main problem for single women (including widows) was a lack of labor. Both married couples and married women whose husbands were absent said that difficulties in hiring traction was the main problem.

Alverson disaggregated the farmers' assessments based on relative wealth. The wealthiest farmers said their main problems were pest and cattle damage, lack of water at the lands, inadequate repair services for implements and tractors, and labor shortages. The middle farmers' problems were: a lack cash for purchasing inputs, labor shortages, pest and cattle damage, and a lack of water at the lands. Poor farmers said draft power was the main problem, followed by labor shortages, lack of implements, not enough seed, and cattle damage. Alverson further explained that the reasons for labor shortages differed depending on wealth. The wealthiest farmers faced a shortage in harvesting and threshing due to their large scale of production, while the poorest had too little labor for plowing and weeding.

Fortmann asked respondents to identify the main problems which kept them from growing more crops. Separate results were presented for male-headed versus female-headed households. Overall, the main problems (aside from lack of rain, of course) were poor land, lack of seed, lack of draft animals, labor shortages, lack of land, lack of implements and weak draft animals (in order of importance). A significantly higher proportion of female-headed households than male-headed households reported that seed shortages, labor shortages and a lack of draft were major constraints.

Gaosegelwe, et al. did not rank the relative importance of problems for farmers in the Ngamiland area. The four most consistently mentioned problems were: lack of draft, lack of labor, crop damage, and lack of seed.

In general, the problems reported by farmers elsewhere in Botswana echo those mentioned by farmers in Shoshong and Makwate. Lack of draft or money to hire draft is the main problem facing poorer farmers. Once draft-dependent households can get the money to hire traction (or exchange labor), they often get poor germination. If good germination is achieved, most households--but particularly those draft-controlling households able to plant large areas--run into labor problems in getting their fields weeded and harvested. Meanwhile, the potential harvest is constantly under attack from birds, cattle, other stock, and wild animals. In the end, many of the poorer households do not even harvest enough that they have a secure supply of seed for the following season.

Given the above scenario, it is no wonder farmers perceive resource constraints as dominating, and hesitate to consider many of the extension recommendations which merely aggravate cash, traction, and labor resource constraints.

H. ROLES IN DECISION MAKING

This section presents information on the relative roles of resident adults in decisions about crop production activities. Roles in decision making were investigated in order to make sure the correct individuals could be contacted about proposed changes. The research was motivated by earlier findings on the gender division of labor and the male bias of the extension service [Bettles, 1984; Fortmann, 1985].

In one of the surveys of the 1985 DUMI Study, male household heads, female household heads, females spouses and adult children adults were asked to rank their relative roles in decision-making. The categorical responses included the following: "decide alone," "discuss with others but have the main role in deciding," "decide jointly with others," "discuss alternatives but others decide," and "not involved in the decision."

The series of individual interviews showed that most decisions are made jointly by adults after a discussion of alternatives. The relative influence of adult children varied but, as a rule, children did not play a major role. Three basic patterns of decision roles were identified for different types of decisions.

The most common pattern of decision making was for joint decision making in households with a male head and spouse, the head alone in female-headed households, and with children having relatively little say in both types of households. This pattern prevailed for decisions about hiring or hiring out labor or traction, whether to cooperate with other households, whether to try new cropping practices, and whether to sell crops. The same basic pattern prevailed, except that males within male-headed households had a slightly stronger role, for the decision whether to use non-household labor for weeding. The joint decision making pattern was also observed with respect to decisions about helping non-household family members, except that children played a greater role in this decision.

In a second pattern, males dominated decision making, even in female-headed households. This pattern was found for the decisions when to start plowing during the year and whether traction animals were fit to plow. Men in male-headed households also were dominant in the decisions about when to plant vis-a-vis a given rain and about the adequacy of soil moisture. Female heads of households assumed control of these decision for their households.

The third pattern involved a dominant role for females in both male-headed and female-headed households. This pattern prevailed for the selection of seed to plant, and decisions about replanting or weeding.

To further characterize the patterns of decision making, indices of relative control were calculated for each decision. For each decision, the index of relative control represents the perceived sense of control for each respondent category relative to other household members. The lower the index, the greater the perceived sense of control for that group. The indices of relative control are presented in Table 4.8. (The procedures for calculating the indices are described in the notes to the table.)

The indices of relative control show that it primarily was a person's position in the household, rather than just gender, which determined roles in decision making. Female heads of households had the greatest individual control over decisions because there often were no

TABLE 4.8: ROLES IN DECISION-MAKING, 1985

	MALE HEADS	FEMALE HEADS	FEMALE SPOUSES	SONS/ DAUGHT.
	(Indices of Relative Control/a)			
WHETHER DRAFT ANIMALS FIT	56	107	112	121
WHEN TO PLANT VIA RAINS	68	88	115	121
WHEN TO START PLOWING	72	93	112	118
WHETHER SOIL MOISTURE OKAY	82	77	111	120
TO HIRE-IN LABOR/TRACTION	92	77	108	115
TO HIRE-OUT LABOR/TRACTION	101	73	112	108
TO SELL CROPS	102	61	106	119
TO USE NON-HH WEEDING LABOR	104	68	104	114
TO ENTER COOP ARRANGEMENT	105	79	108	104
WHETHER & WHEN TO REPLANT	108	60	92	124
TO HELP NON-HH FAMILY	109	75	112	100
HOW MUCH SEED TO PLANT	119	54	82	128
WHEN TO WEED	146	59	59	120
AVERAGE	96	75	104	116

Source: 1985 Decision Unit Profile Survey.

a. Each respondent ranked his/her own role in each decision from 1 (=decide alone) to 5 (= not even involved in the decision). The numer of respondents were as follows: 23 male heads, 19 female heads, 21 female spouses, and 30 daughters and sons. For each respondent category, the index of control was calculated as the mean value for that group relative to the average value for all groups combined (multiplied by 100). The lower the index, the greater the perceived sense of control for that group.

other senior males or females resident. There were, however, gender related decision roles in households having a male head and female spouse. In general, males controlled decisions relating to the plowing operation and females controlled decisions about post-planting practices. There was less gender bias in decisions about resource acquisition and disposal (include crop sales) than in production decisions.

The findings on decision making patterns are, for the most part, consistent with those reported by Bond [1974]. Due to her survey method (each respondent was only asked who was responsible for each of four crop production decisions), Bond: (a) understated the role of women in seed selection, (b) did not identify the important role of women in decisions about post-planting operations, (c) seemingly overstated the role of women in decisions about traction use and timing, and (d) did not fully represent the extent to which decisions are made by consensus. There not only is a free exchange of ideas, several individuals often are involved in actually making decisions even if one is the principal decision maker. Nevertheless, Bond made an invaluable contribution when she documented the existence of distinct decision roles and showed that the extension service must work with directly with women.

I. CONCLUSIONS AND IMPLICATIONS

This chapter has described crop systems management, emphasizing: (a) farmers' priorities and perceptions, and (b) the diversity in existing practices. This section highlights key findings and synthesizes implications for arable farming development priorities.

1. CROPS AND VARIETIES

Farmers were unanimous in saying their primary objective was to grow food for home consumption. Secondary objectives were to produce a surplus to sell, to have a diverse diet and to minimize the risk of complete crop failure. Based on farmers' objectives, the Ministry appears to be on the right track in emphasizing sorghum and cowpea research.

With reference to sorghum variety screening, length of growing time and drought resistance were considered to be the most important characteristics. Still, farmers were not ready to sacrifice the taste of their traditional varieties to get the short growing periods of Red Swazi and 8-D. Cowpea screening should, as it currently does, focus on at least two distinct types of cowpea plants: (a) a quick growing, determinant plant for seed production and, (b) a long season, spreading plant for leaf production. Farmers also like plants such as Blackeye and Sri Lanka which combine the characteristics. Therefore, an intermediate plant would be a third screening goal.

There is enough interest in groundnuts and jugo beans to warrant additional research, if only in the context of on-farm research. The top priority is to identify drought resistant, quicker maturing varieties. Farmers do not use groundnuts for oil, so oil extraction should not be a criterion for variety selection.

In general, the screening of all crops and varieties needs to pay more attention to farmers' standard production practices. For example, most farmers plant their cowpeas and sorghum into drying soils. As part of the varietal screening process, establishment should be evaluated when seeds are broadcasted into drying soil moisture conditions. The tendency of farmers to plant late in the season also should be considered. Quicker growing crops/varieties and crops which produce products even if there is not time to mature (such as cowpea leaves) are options for farmers who plant late.

2. TRACTION USE AND ACCESS

One of the main challenges facing the Ministry is to help farmers take advantage of rapidly changing patterns of traction use and draft access. Although no one knows the extent to which the trends will reverse themselves after the drought, the trends do have some positive implications for arable farming development.

One positive implication of the trend toward tractor hire is the opportunity to impact on many farms by concentrating on appropriate implements and practices for a much smaller number of farmers. Even more important, the control, speed and draft power of tractors (even with low horsepower) create several additional options for field operations, including sub-soiling, stubble sweeping, and inter-row cultivating.

Use of donkeys has several advantages, particularly for the poor. Timing can be controlled and more area can be plowed than when one hires traction. An entire donkey team costs only the equivalent of one ox or cow. Moreover, donkeys survive better in drought and generally require less management. Row planting can be done with one or two donkeys, while row planting with untrained oxen is impractical. Finally, donkeys can be used throughout the year to pull carts, reducing household maintenance labor requirements and freeing additional labor for arable farming.

All things considered, the Ministry should make promotion of donkey traction one of its top priorities. Options to take advantage of the speed and draft of tractors would be another priority. Efforts to improve or maintain the traditional oxen-based plowing system should be a low priority, at least in the Central Region.

3. TIMING OF PLOWING

Several timing issues were addressed in the research on traction use and plowing. In each case, farmers cited several reasons why they use their current timing strategy, rather than follow the recommendations and practices of researchers. The Ministry should take farmers' timing strategies as a given and concentrate on interventions which are consistent with their strategies. Several examples can be given:

a. Row planting into drying soils might be more successful if done with an injection planter, rather than the current (shallow) planters.
b. The option of dry planting should be examined. Under the right conditions, dry plantings often establish better than do wet plantings.
c. The advantages of seed soaking could again be examined (as they were inconclusively during the 1970s) as a option for planting into drying soils.
d. Fungicide seed treatment might be useful for dry plantings, to protect the seed until the following rain.

4. PRODUCTION PRACTICES

There were two main findings in the research on production practices. First, there was substantial heterogeneity in traditional practices. Second, many farmers had favorable perceptions of several recommended practices but were not using them due to resource constraints.

To take advantage of the diversity of traditional practices, a greater share of research resources needs to be shifted from tillage systems development work to technical and economic assessments of farmers' current practices. It should be quite feasible to address the following issues with minor investments of existing research resources:

a. What criteria should farmers use for site selection? Right now, farmers plant their groundnuts and jugo beans on sandier soils. Are there other criteria which might be helpful? For example, the depth and texture of the soil may reflect water holding capacity, which in turn is related to the benefit from double plowing (see Chapter V).
b. Farmers currently plant secondary crops in their crop mixtures at only 1:25 or even 1:50 ratios relative to their sorghum. Can the ratio increase without hurting sorghum production?
c. What are the best cowpea defoliation strategies for different types of cowpea plants?
d. What is the threshhold level of plant stand, below which it would make more sense to replow and plant the entire acre rather than gap fill?
e. Does the extra production from hilling jugo beans and groundnuts (to facilitate pegging) justify the labor investment.
f. Can women start their weeding earlier without a drop in yields (1-2 weeks after emergence rather than 4-6 weeks), thereby reducing the labor constraint when weeding overlaps with birdscaring and early harvesting?

Since most farmers do not have the resources to implement the current recommendations, the recommendations need to be targeted to particular environmental circumstances. Targeting will maximize the expected benefit and minimize the resources required for implementation. Some examples where this approach might be tried are as follows:

a. Hand planting might be feasible (and profitable) if targeted to high value crops, planted on high potential sites.

b. Thinning might be a better use of labor than weeding if done only in the few spots where stands exceed 100,000 to 125,000 plants per hectare.

c. Harvesting only some residues for high priority animals such as calves and kids might be profitable and would not take too much labor.

d. Manuring could be concentrated on a small, appropriate site for growing maize for green mealies (corn on the cob).

5. POST-HARVEST PRACTICES

Post-harvest research will not be a priority until the drought is over. However, in the medium term horizon, there are options for improvement. First, farmers have a minimal set of criteria for selecting seed. If simple, but more comprehensive criteria can be developed, this would be a "non-resource using" intervention--which is always useful.

Second, the management and harvesting of crop residues is likely to be of increasing importance over time. Residue management is not part of traditional crop systems management because, until recently, few fields were fenced.

Third, storage losses can be a problem for sorghum and appear to be a major problem for cowpeas. The Ministry might reactivate its storage extension program from the late 1960s and early 1970s, in which mobile teams circulated to provide storage advice and to help treat seed [Hamilton, 1975].

6. DECISION BEHAVIOR

The research on decision behavior showed that: (a) farmers felt that resource constraints are the main factors limiting increased production, and (b) there were gender roles in production decisions corresponding to the gender bias in fieldwork.

Given farmers' current concerns with resource constraints, along with the government's commitment to equitable development, the Ministry's emphasis on ALDEP and drought relief appears warranted. The proposals presented in this thesis on options to resource transfers are not meant to imply that resource transfers are not useful or are undesirable.

Finally, research activities clearly need to be targeted to individuals within households, not only to particular household types. Interventions related to the plowing operation should be targeted toward males and should relate to the problems perceived by males. Interventions targeted toward crop/variety selection or post-establishment operations should be designed and evaluated in relation to the problems and interests of females. The extension service also should taken into account gender roles in decision making and fieldwork.

V. CROPPING OUTCOMES AND THE RESULTS OF ON-FARM TRIALS

This chapter presents an overview of cropping outcomes for the Shoshong and Makwate households, gives a historical perspective on experiment station and on-farm research in Botswana, and provides an assessment of the production practices examined in on-farm trials. The objectives are to: (a) characterize differences in outcomes by household type, (b) determine the returns to the resources invested in arable farming, (c) clarify the rationale for the Central Region experimentation program, (d) distinguish promising interventions from those that seem less promising, and (e) analyze whether the most promising interventions are profitable enough to justify adoption.

A. CROPPING OUTCOMES

Several cropping outcomes were examined, including days of planting, area planted, percent of area and plots weeded and abandoned, yields, and returns to labor, management and traction.

1. 1982-83 SEASON AND "NORMAL" SEASONS

In the 1983 Crop Management Survey, farmers were asked how many "acres" they planted during the 1982-83 season, and how many they plant in years with normal rainfall. ("Acres" are a traditional plowing unit which, on average, are equal to about one-third hectare.) Farmers also were asked about the number of days on which some planting was done. The number of planting days and area planted reflect the ability of different households to take advantage of planting rains. Results are summarized in Table 5.1.

Due to the drought, the number of planting days and the area planted were less in 1982-83 than in normal seasons for all household categories. The percentage differences between good seasons and the 1982-83 drought season were greater for female-headed compared to male-headed households, and for draft-dependent compared to draft-controlling households. The relatively greater effects of drought on draft-dependent households was also noted by Vierich and Sheppard [1979].

TABLE 5.1: DAYS OF PLANTING AND ACRES PLANTED; RECALL DATA FOR "GOOD SEASONS", 1982-83, AND 1984-85

	GOOD SEASON		1982-83 SEASON		1984-85 SEASON	
	DAYS	ACRES/a	DAYS	ACRES	DAYS	ACRES
VILLAGE:						
Shoshong East	7	14	5	9	2	8
Makwate	11	18	7	10	5	10
PRIMARY TRACTION:						
Donkey	11	18	7	10	6	10
Cattle	8	15	8	10	3	7
Tractor	4	13	2	7	2	10
DRAFT ACCESS:						
Control	11	18	8	11	6	11
Dependent	5	14	2	6	2	8
HOUSEHOLD HEAD:						
Male	9	16	7	11	5	11
Female	9	15	5	7	3	8
ALL	9	16	6	9	4	9

Sources: 1983 Crop Management Survey; 1983 DUMI Study.
a. Acres refers to traditional acres. Traditional acres average just over 1/3 hectare. Donkey plowed acres generally are smaller, around .25 ha., while tractor plowed acres average around .75 hectares.

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Respondents also were asked to estimate their total annual production of the major crops for the 1982-83 season and for a normal season. Little was produced in either Makwate or Shoshong East in 1983. Findings for normal production levels are summarized in Table 5.2.

TABLE 5.2: NORMAL FARM PRODUCTION OF MAJOR CROPS, 1983

	SORGHUM/a	MAIZE	COWPEAS	JUGO B.	MELONS
VILLAGE:					
Shoshong East	752/b	65	56	37	489
Makwate	343/b	108	39	45	586
HOUSEHOLD HEAD:					
Male	701/b	125/b	68/b	53/b	560
Female	431/b	23/b	28/b	21/b	434
DRAFT ACCESS:					
Control	636	118/b	70/b	54/b	539
Dependent	527	36/b	20/b	21/b	474
CATTLE OWNED:					
15 or Less	353/b	32/b	33	26	503
16 or More	871/b	136/b	68	54	517

Source: 1983 Crop Management Survey.
a. Production refers to kgs. for all crops but the number of melons.
b. Means for same category and crop followed by "b" are significantly different at a .95 confidence level.

The estimated normal production levels for sorghum were greater for Shoshong East, male-headed, draft-controlling, and cattle-rich households. For male-headed versus female-headed households and draft-controlling versus draft-dependent households, there were significant differences reported for nearly all the major crops. The RIDS also showed significant differences in production associated with gender of head and cattle assets [Lucas, 1985].

The relationships identified between household types and estimated production levels were reconfirmed in additional analyses of cropping outcomes during the following two seasons.

2. 1983-84 Season

An overview of the days of plowing, area plowed and sorghum harvested in 1983-84 by the 27 MVRU Survey households is presented in Table 5.3. Makwate, male-headed and draft-controlling households plowed many more days on average than did Shoshong East, female-headed, and draft-dependent households, respectively. Cattle-rich households did not plow on more days than cattle-poor households because many of them hired tractors.

Male headed, cattle-rich and draft-controlling households all plowed more area than their comparison groups--in total, per person plowing, and per consumer equivalent. A positive association between area plowed and cattle assets has been reported in several studies, including the FAO [1974], CSO [1976] and Vierich and Sheppard [1979].

Male-headed, cattle-rich and draft-controlling households also obtained better results than their counterparts, in terms of the proportion of households harvesting, total amount harvested, and amount harvested per hectare, per consumer, and per hour. The differences were particular dramatic depending on draft access.

The association between resource access (cattle and draft) and yields deserves note. Several studies based on years with good rainfall have not reported an association between yields and resource access (for example, the RIDS [Lucas, 1985] and Alverson [1979]). Instead, differences in production generally have been due to a larger amount of area planted. During drought seasons, however, lack of draft access and control over timing become particularly crucial, and affect yields as

TABLE 5.3: DAYS OF PLOWING, AREA PLOWED, SORGHUM HARVESTED, 1983-84

	VILLAGE		SEX OF HEAD		CATTLE ASSETS		DRAFT ACCESS		
	SHOSHONG	MAKWATE	MALE	FEMALE	36+	0-35	OWN	DEPENDENT	ALL
% FARMS WHICH PLOWED	82	100	94	80	100	81	100	73	78
DAYS OF PLOWING	4.1	10.8	8.2	3.7	7.1	6.2	9.8	1.9	6.6
AREA PLOWED:									
Total	3.4	4.3	4.5	2.5	5.7	2.4	5.2	1.7	3.8
Per Person Plowing	1.4	1.1	1.5	0.9	1.8	0.9	1.5	0.6	1.3
Per Consumer Equiv./a	0.6	0.6	0.7	0.4	0.9	0.4	0.8	0.2	0.6
Per Day	1.2	0.4	0.9	0.8	1.3	0.5	0.8	1.0	0.9
PERCENT OF FARMS HARVESTING ANY SORGHUM	53	40	53	40	73	31	63	27	48
KGS. SORGHUM HARVESTED:/b									
Total	287	420	454	139	488	232	532	51	336
Per Hectare	64	87	89	42	72	75	98	25	74
Per Consumer Equiv.	44	58	62	26	74	40	74	5	49
Per Hour:									
With Field Mainten.	2.2	2.5	3.1	1.1	5.1	1.0	c	c	2.4
Without Maintenance	3.5	3.4	4.2	1.8	7.5	1.5	c	c	3.4

Source: 1983-84 MVRU Survey and plot monitoring.
a. Consumer units weights: age 0-4 = 0.20; age 5-9 = 0.50; age 10-15 = 0.75; adult women = 0.90; adult men = 1.00 These weights are based on FAO estimated caloric requirements.
b. Kgs. sorghum based on a standard conversion of 70 kgs. per bag of threshed grain.
c. Figures on fieldwork hours by draft access category are not available.

well as area plowed.

3. 1984-85 SEASON

During the 1984-85 season, the analysis of cropping outcomes was based only on the 13 households which participated in the abridged MVRU Survey. All but one of these households controlled traction resources. The objective was to evaluate cropping outcomes and enterprise returns for draft-controlling households.

The season was again dominated by drought conditions. An average area of 6.4 hectares was planted per household but only two-thirds of the area planted was weeded or harvested. Only nine of the 13 households harvested any grain. Across all 13 households, grain production averaged 221 kgs. of sorghum and 23 kgs. of cowpeas. Average sorghum yields were only 36 kgs. per hectare.

A crop enterprise budget for the thirteen farms participating in the income and plot monitoring program is presented in Table 5.4. Technical data in the budget are area weighted. Local market prices were used for seed, sorghum, maize and beans. The prices were obtained through a regional survey of trading establishments (see Chapter VI). The official BAMB prices were not used since no farmers traded through BAMB. It was difficult to determine an appropriate price for sweet reed, morogo and melons, since these items usually are neither purchased nor sold by farmers in Shoshong and Makwate. To value these items, the most common sale price in Mahalapye village was used, minus an estimated transport charge. This represents the opportunity cost for home consumption.

No attempt was made to establish prices for farmers' land, labor, traction, or management. There is no formal market for land or

TABLE 5.4: CROP ENTERPRISE BUDGET, 1984-85

	ALL FARMERS		IF HARVESTED	
	PER FARM	PER HA.	PER FARM	PER HA.
LEVEL OF PRODUCTION				
Area Plowed (ha.)	6.4	--	8.0	--
Area Weeded	4.0	--	6.1	--
Area Harvested	4.2	--	6.6	--
INPUTS				
Seed Planted (kgs.)	39.5	6.2	44.9	6.2
Traction Hours	63.3	10.0	80.6	11.5
Person-Hours:				
Plowing	183	29	248	35
Weeding	149	23	222	32
Birdscaring/a	297	46	467	67
Harvesting	113	18	177	25
Threshing	28	4	44	6
Maintenance	116	24	145	18
PRODUCTION				
Sorghum (kgs.)	221	34.5	348	43.5
Cowpeas (kgs.)	23	3.6	33	4.1
Maize (kgs.)	1.3	0.2	2	0.3
Misc. Beans (kgs.)	3.2	0.5	5	0.6
Melons (number)	938	147	1475	184
Morogo (fresh sacks)	5	0.8	7.6	1.0
Sweet Reed (stalks)	30	4.7	47	5.9
VALUE OF PRODUCTION/b	249.64	39.01	386.40	48.30
COST OF SEED	20.15	3.15	22.90	2.86
GROSS MARGIN				
No Labor, Tract. Cost	229.49	35.86	363.50	45.44
Per Hour	.26	---	.28	---
FIXED COSTS				
Equipment	53.90	8.42	65.38	8.17
Lands Buildings/i	33.67	5.26	35.17	4.40
NET MARGIN				
No Labor, Trac. Cost	141.92	22.18	262.95	32.87
Per Hour	.16	---	.20	---

Source: 1984-85 MVRU and plot monitoring.

a. For this budget, 8 hours a day are assumed for birdscaring.

b. The following prices were used: sorghum - 39t/kg; maize - 60t/kg; cowpeas, other beans - P1.56/kg; morogo P5.00 per fresh (70 kg.) sac; melons 10t each; sweet reed 10t/stalk.

agricultural labor [Duggan, 1979] and the number of assumptions required to value home use of owned traction animals would make any particular figure meaningless. Consequently, the gross and net margins presented in the table represent returns to farmers' land, labor, traction and management.

The gross margin for crop production was approximately P386 per farm and P48 per hectare for those farms which harvested. The gross return to farmers' land, labor, traction, and management was approximately P0.28 per hour (P0.26 for all farmers).

To calculate a net margin, depreciation charges were subtracted for plows, hand tools, receptacles, and lands buildings. For plows, a straight line depreciation of current value was used. The plows averaged nine years of age and it was assumed that they could last, on average, five more years with no salvage value. The replacement value was used for hand tools and receptacles, depreciated over five years. The five years was based on farmers' estimates of the normal useful life of these items. The charge for buildings was based on the average value of lands buildings for farmers who did not live at the lands except for when active in cropping (all but two farmers), depreciated over ten years with no salvage value. While buildings might have a much longer life when maintained, it can reasonably be assumed that an investment equal to ten percent of the value of the buildings would be required to maintain them in reasonable condition.

Based on the above assumptions, the net return was approximately P0.20 for the seven farmers which harvested and P0.16 for all farmers combined. Even without deducting a charge for traction, these returns to farmers labor, traction and management in the 1984-85 season were below urban or even village wages.

Data from the 1981-82 National Farm Management Survey (also a drought season) showed even lower returns to arable farming [Boykin, 1983]. Based on 165 households from 11 extension areas, the gross margins were only P77 per farm, or P19 per hectare. However, the gross margin per hour was about the same as the MVRU Survey data, P0.30 per hour (because fewer hours were reported). The NFMS data also showed that male-headed households and "draft-adequate" households plowed more area and produced more than did female-headed households and households without adequate draft resources, respectively.

B. HISTORICAL PERSPECTIVE ON AGRICULTURAL EXPERIMENTATION IN BOTSWANA

Arable production research in Botswana was initiated in 1936 on a small experimental field in Mahalapye [ARS, 1978]. During the next thirty years, the field at Mahalapye remained the main station. There was a restricted research program, focused on: (a) assessments of new crops and varieties, (b) reactions of the new varieties to different fertilizer levels and selected husbandry practices (such as row spacing), (c) constraints on the introduction of cash crops--particularly cotton, and (d) practices for maintaining soil fertility--particularly crop rotations [ESM, 1965].

Throughout the pre-independence period, most technical researchers assumed that Batswana farmers would soon adopt the capital intensive, row planting farming methods then being used in South Africa [ARS, 1978]. Their objective was to identify an appropriate package of "modern farming methods" for progressive farmers [ESM, 1965].

Substantial progress was made. The greatest success was in identifying appropriate staple food grain varieties. Information was also generated on the importance of winter plowing and appropriate timing of field operations. However, the cotton work was a failure because no solution could be found for the American bollworm. Also, plant spacing trials did not reveal that any particular pattern was most advantageous, and fertilizer trials often were inconclusive [ARS, 1978].

Over time a seemingly effective package of "modern farming" techniques was developed. The main elements of the package were as follows: (a) winter plowing, (b) row planting on early spring rains, (c) regular weeding, (d) use of quick maturing varieties, (e) crop rotations, and (g) selective use of manure and fertilizer (mainly phosphate) [ESM, 1965]. Beginning in 1962, this package was introduced in a series of steps to a selected number of "pupil farmers." If farmers eventually adopted all the components of the package, they became "master farmers" (see Chapter VI).

Just prior to independence, there was a great deal of confidence in the package. The Economic Survey Mission, which prepared the last development plan prior to independence, said the the pupil farmers using the package were "strikingly successful" in increasing yields, producing even during drought, adding cash crops to their cropping systems, and increasing the area plowed [ESM, 1965: 41].

Soon after independence, the main experiment station was shifted to Sebele and research continued on dryland farming practices, crop and variety selection, and plant protection. However, the top priority of the government was to increase the number of extension workers, in order to expand their coverage and increase the benefits from the existing package [MFDP, 1968]. In the 1970 NDP, the government declared that production could be doubled or tripled by increasing the number of pupil farmers [MFDP, 1970].

In the next National Development Plan, only three years later, there was a substantial change in tone [MFDP, 1973]. When rainfall recovered during the 1970s, the relative advantage of the techniques being used by the pupil farmers was less than expected. Equally important, national agricultural statistics revealed how atypical the pupil farmers were. In addition, there was a growing concern with the effects of existing farming techniques on the environment [Gibbon, Harvey, Hubbard, 1974]. Consequently, there was a renewed emphasis on research, and national research policy shifted to focus on risk reducing and soil conserving practices.

During the 1970s, research at Sebele--and at sub-stations located at Goodhope, Mahalapye, Motopi and Moshu--included trials on dryland crop varieties, fertilizers, crop rotations, tillage systems, and horticulture crops. Much of the research at Sebele, and off-station, was conducted through donor funded projects, including a FAO fertilizer project, a British bird pest research project, UNDP/FAO research in the Okavango, and a U.S. crop improvement research project.

The backbone of arable production research between 1971 and 1983 was the British sponsored Dryland Farming Research Scheme (DLFRS). The objectives of DLFRS were to study factors limiting arable production and to investigate means of making crop production more reliable. During Phase I, which lasted from 1971 to 1974, DLFRS took an "applied research" approach--as directed by the Ministry. By 1974, a minimum tillage cropping system was developed, derived from techniques used in the U.S.

The DLFRS system was based on the Makgonatsotlhe two-wheeled tool bar and included the following: (a) crop rotation including bare fallowing before sorghum, (b) maintaining a weed free environment using blade sweeps, (c) sub-soil plowing (with a chisel) during autumn, (d) row planting after the first spring rains, (e) inter-row weeding immediately after emergence and whenever necessary afterwards, (f) thinning, (g) top dressing N in wet years, (h) breaking the surface to improve rainfall infiltration, (i) harvesting early in the season, and (j) sweeping crop stubble immediately following harvest [Gibbon, Harvey, Hubbard, 1974]. To prevent runoff, all operations were carried out on the contour. With this system, yields on-station were more than 600 percent higher than the national average [DLFRS, 1977].

In 1975, two companion British projects were established to begin testing the recommendations developed by DLFRS on farmers' fields. The Evaluation of Farming Systems and Implements Project (EFSAIP) had both on-station and on-farm research activities, and took over responsibility for implements development and testing. The Integrated Farming Pilot Project (IFPP) was established in the Department of Agricultural Field Services in order to provide an extension situation under which technologies developed by DLFRS and screened by EFSAIP could be tested under farmers' conditions with farmers' management.

It was quickly found that the Makgonatsotlhe system did not work when moved off-station. In EFSAIP trials in 1976-77 and 1977-78, the Makgonatsotlhe system gave higher yields than the traditional broadcast system but the gross margin per hectare (not including capital charges) was negative [EFSAIP, 1978; 1979; Gulbrandsen, 1980]. Also, the amount of grain produced per hour invested was lower than for the traditional check plots [Alverson and Srivastava, 1980]. However, an intermediate system involving autumn plowing and spring planting (using a mechanized method of furrow plow-planting) slightly outperformed the traditional system in 1976-77 and did significantly better in the 1977-78 season. Similarly in IFPP trials, the Makgonatsotlhe system did worse than traditional broadcasting but a "modified traditional" mechanical row planting system increased the gross margin per hectare by 33 percent [Gulbrandsen, 1980].

During the late 1970s, the Makgonatsotlhe system was abandoned. In addition to modest yields benefits, the equipment was expensive and did not reduce draft requirements as expected. Many of the associated cropping systems recommendations could not be implemented by farmers. As Gibbons had said, "to raise output significantly the system needs to be applied as a whole and not as a series of isolated steps." [Gibbons, n.d,: 7]. Unfortunately, farmers generally cannot and do not adopt entire packages.

In 1982, when on-farm research began in the Central Region, there was a great deal of uncertainty about appropriate crop production practices. There were disagreements among technical researchers over the advantages of row planting versus broadcasting, sole versus intercropping, and the profitability of using fertilizer [Lightfoot, 1983]. The possibility of pesticides or herbicides was not seriously considered, given the low yield base. Even the prevailing plant population recommendation for sorghum did not provide much guidance; 45,000 plants plus or minus 20,000 plants was recommended for much of the country.

The extension service continued to recommend many of the practices originally developed for the pupil farmers, but there was little research supporting the recommendations. Moreover, as the national statistical data showed, few farmers were paying any attention to the recommendations.

C. CENTRAL REGION ON-FARM TRIALS

Between 1982 and 1986, many interventions were tested in a variety of experimentation formats. The trials program primarily focused on modifications in the traditional broadcast, single plow system. Emphasis was given to minor modifications, generally involving an additional tillage and/or the introduction of more precise planting methods. More substantial modifications were investigated beginning the third season, but only in RI trials.

Two other topics were systematically investigated: (a) production of secondary crops and (b) post-establishment plot management practices. Research on secondary crops mainly comprised a series of crop-variety comparison trials, plus attempts to identify specialized planting methods for crops or varieties which established poorly in the traditional broadcast system. Post-establishment plot management practices emerged as an important theme during the third and fourth seasons, primarily in relation to stand adjustment techniques (thinning and replanting). Several planned post-establishment trials were abandoned due to the drought.

In addition to the primary investigations, many issues were addressed on an ad hoc basis. For example, garden plots, manuring and ridging were evaluated--primarily to assess their potential. Some investigations were added in the interest of establishing collaboration with Sebele researchers and researchers from the other on-farm teams.

This section gives an overview of the trials program and a summary of trial results, on a season-by-season basis. The summary of trial results is primarily based on analyses carried out by J. Siebert and presented in ATIP [1986].

1. 1982-83 SEASON

During the first season, the experimentation program consisted of three small trials, all based on issues already under investigation elsewhere in Botswana. The main experiment was a comparison of five planting methods--each representing a different degree of seed placement control. The objective was to evaluate the importance of improved seed placement for sorghum stand establishment and yield. In addition to a broadcast control plot, the methods tested were third furrow hand placement, the EFSAIP plow-planter (a mechanized version of furrow placement), the EFSAIP single row planter, and use of a harrow to cover broadcast seed. The last method was suggested by farmers during the exploratory surveys.

In the second trial, double plowing--once early and once at planting--was assessed at two sites. Double plowing was examined because EFSAIP had found in a "time of planting" trial that double plowing seemed to improve water infiltration and soil tilth, leading to better stand establishment [EFSAIP, 1983].

In addition to the tillage trials, one RI trial was carried out in which three special purpose fodder crops (teff grass, Dolichos lab lab, Bambala millet), as well as the traditional (Tswana) cowpea variety, were undersown following the establishment of a sorghum crop. The objectives were to test crop varieties suitable to undersowing and to evaluate a hand jab planter.

Results for the planting methods trial failed to show significant differences for plant stand establishment. A majority of the comparisons failed to give any grain yield and no yield analysis was carried out. In the two double plowing comparisons, double plowing yielded substantial benefits for plant establishment and grain yield. In the undersowing trial, Tswana cowpeas produced as much vegetative material as any of the special purpose fodders. Farmers said they would prefer cowpeas, because there could be a grain yield.

2. 1983-84 SEASON

In the second season, early plowing was added to the planting methods trial. Sixteen farmers sole plowed (plowed without planting) and later superimposed the different planting methods. Super single phosphate was applied in strips across the sole plowing and planting methods trial. There were statistically significant plant stand and grain yield benefits from double plowing and early plowing plus row planting when compared with the traditional and other tillage-planting systems. However, the differences were not substantial. There were no measurable benefits from the phosphate applications.

The double plowing trial from the first season was modified to include three early tillage options: deep plowing, shallow plowing and harrowing. This was done in order to separate the benefits of early double plowing into effects due to time of the operation versus the depth of plowing. The early plowing strips (implemented at three depths) produced a benefit for stand establishment but the effects were confounded with pocket variability of soil types within fields. Due to drought, grain yield effects due to treatments could not be measured. There was no visible effect due to the depth at which early plowing was done. Harrowing had a negative effect on soil structure and plant growth.

Because of the continued enthusiasm of EFSAIP, the plow planter unit was compared to the traditional broadcast system in a separate FM, FI trial. Few implementations were obtained. The unit was difficult to use when mounted on a single furrow plow (since farmers normally drop the plow when turning at the top of acres). There was little farmer interest in the plow-planter unit.

In response to an observed problem of weak draft animals, six farmers were provided with a supplemental ration of sorghum and cowpea residues for feeding their draft teams. The objective was to maintain animals during the plowing period by providing energy supplements as a complement to existing grazing. (Prior feeding schemes had concentrated on the unrealistic goal of feeding draft teams throughout the winter.)

When provided with residues, the farmers were willing to feed their draft animals prior to plowing but did not want to feed residues at breaks in the plowing operations. Cattle often would not eat the rough residues even when provided (although donkeys did). Overall, it did appeared that neither farmers nor the draft animals were responsive to the concept of a residue harvesting and supplemental feeding scheme.

A secondary crops comparison trial was initiated in order to evaluate stand establishments and relative yields for selected secondary crops, particularly cowpeas, under the traditional broadcast system. Most replications arranged were never implemented due to the drought. Of the comparisons planted, only seven replications of the comparison of cowpea varieties established measurable stands; of these only five produced grain yield. Both Blackeye and Tswana cowpeas emerged better than ER-7 (a determinant variety promoted by the Sebele-based Cowpea CRSP). Tswana and Blackeye cowpeas also produced significantly higher grain yields.

A relatively minor birdscaring scheme, based on a polyethylene "hum line," was added late in the season. The hum line was installed on some sorghum plots in four farmers' fields. Bird damage was reduced to an extent, but doves seemingly were unaffected. To be installed at a heavy enough concentration to be effective, the cost of the "hum lines" would be prohibitive.

3. 1984-85 SEASON

During the third season, an RM,RI "steps in technology" factorial trial was implemented in order to assess combinations of tillage-planting methods. The experimental treatments were sub-soiling, early plowing, phosphate fertilizer, and several planting methods. The objective of the factorial trial was to evaluate the technical performance of various inputs. Sub-soiling and phosphate fertilizer gave significant, but not substantial, benefits for sorghum grain yield. The only substantial treatment main effect was from row planting. There were significant interactions with location.

Two "design" activities were not based on a formal trials. One involved an RM,RI technical evaluation of a ridging plow and a ridging planter. Neither piece of ridging equipment performed well on previously untilled soil. When used on previously tilled soils, ridge construction was poor by both units and the ridges disappeared following a heavy rainfall. Emergence of planted seed was poor.

The second design activity was an examination of intensive production, involving early planting and the addition of corral manure at sites selected for high production potential (usually having deeper soils). The intensive production plots also failed. Stand establishment was adequate on only three of five sites and there was no measurable difference in grain yield due to the corral manure applications.

The FI tillage-planting methods trial was modified to focus on early plowing plus row planting and double plowing, versus the traditional system. Sole plowing was targeted to drying soil moisture, to reduce the opportunity cost of the sole plowing. The planting methods strips were implemented on two days, one with good soil moisture and one with drying soil moisture. The benefit of early plowing for grain yield was statistically significant, but not large, as in the previous season. Most farmers were not able to follow the plowing moisture guideline. They complained that the condition of their animals would not permit the harder work on drying soils and the abrasive action of the dry soil would quickly ruin a plow share.

A modified version of the secondary crops comparison trial was again tested during the third season. Sri Lanka cowpeas (purchased and imported by the government due to a seed shortage) and mung bean established and yielded well. Blackeye and Tswana cowpeas established well but gave an erratic yield performance. ER-7 cowpea was erratic in establishment but yielded well on a per plant basis. Groundnuts established and yielded poorly. Tepary bean gave adequate establishment but limited grain yield.

As a complement to the cropping comparison trial, a trial comparing hand planting versus broadcast planting of four cowpea varieties was implemented. The objective was to test differences in establishment between hand planting (with control over seed depth placement) and broadcast planting after having controlled for soil moisture (by making all plantings on good moisture). Good emergence plant stands were obtained for all varieties and both planting methods (ranging from 36,000 to 53,000 plants per hectare). Neither planting methods nor plant methods by variety effects were significant. Yields were low but, except for Sri Lanka, were much higher than those in the cropping comparison trial. The results showed that adequate stands of the new cowpeas, ER-7 and Sri Lanka, are obtainable using the standard broadcast system.

4. 1985-86 SEASON

During the fourth year, two RM,RI tillage-planting trials were implemented. One was the second year of the "steps in technology" factorial trial. Grain yield results for double plowing and row planting did not differ substantially from prior years. Most of the significant responses to early plowing and phosphate were obtained at environments with the highest total water holding capacity and when drought conditions immediately followed planting. Row planting gave significant benefits for grain yield regardless of the soil type or rainfall pattern.

The second RM,RI tillage trial focused on several "water harvesting" tillage-planting systems, including deep ripping, minimum tillage and strip cultivation, as well as combinations of some of the components tested in the other RI trial. The strip tillage systems were difficult to implement, produced smaller and fewer plants, had unacceptable weed burdens along the untilled strips, and resulted in very low yields.

In the FI program, separate experiments were set-up for row planting and double plowing. Double plowing was compared to the traditional system at more than thirty sites in order to evaluate the relative benefits across soil and weed environments. A yield increase of 94 percent was obtained across 31 sites. Yield levels, however, were quite low for both the traditional and double plowing systems. Weed control was significantly improved through double plowing.

Three tillage-planting systems were compared for row planting: (a) plowing and planting on the same day, (b) early plowing followed by row planting on a subsequent rain, and (c) early plowing followed by a weed control tillage (cultivating or harrowing) and row planting after a subsequent rain. The goal was to evaluate the benefits of early plowing (and the associated problem of weed development before planting) versus the standard row plant system based on same day plowing. The trial was severely affected by poor moisture conditions. Due to the absence of rainfall during the early planting period, little rainfall was conserved through early plowing and weed control was not a serious issue in any of the plots.

Following two years of the RM,FI cropping comparison trial, sole cropping of secondary crops (in small plots) was examined in an FM,FI framework in the 1985-86 season. Small plots were recommended because: (a) potential labor conflicts between sorghum and secondary crops could be minimized, and (b) small plots would be sufficient to meet the limited demand for secondary crops. The objectives of the trial were to: (a) facilitate farmer assessments of the advantages and disadvantages of sole cropping and (b) collect data for crop specific enterprise analysis.

The farmers who tried to implement the sole planting trial encountered many problems. A late start to the rains prevented many farmers from planting jugo beans or groundnuts. Plant establishment for most crops was less than had been hoped, in part because the recommended soil moisture guidelines were not well followed. Even when reasonable establishment was achieved, insect pests, heat, drought, disease and wild animal damage destroyed most plots.

Hand furrow planting was again examined, this time as an option for secondary crops that do not establish consistently in the traditional broadcast system. Few implementations were achieved. Based on limited observations, there did not appear to be any advantage in hand furrow planting for sunflower, groundnuts or jugo beans. The first two established poorly regardless of the planting system, while jugo beans established well under broadcast. There was somewhat better establishment with hand furrow planting for ER-7 cowpeas and maize, but farmers expressed little or no interest in pursuing hand furrow planting on their own.

Until the fourth season, the main strategy for improving plant stands was to modify the tillage-planting system. However, this strategy was practical only for draft-controlling households--as low trials implementation rates demonstrated. Research on a strategy for draft-dependent households was initiated during the fourth season. The strategy was to invest labor in post-establishment stand management, including gap filling and thinning.

Hand planting for gap filling was examined for sorghum and millet. Millet (cv. Serere 6-A) and sorghum (cv. 65-D) were planted in paired plots with two replications. On some fields, the main plots were split into dry versus wet planting sub-plots. The average planting time was only 10.2 hours per hectare. Acceptable stands were achieved: 45,663 plants per hectare for sorghum and 42,428 for millet. Dry plantings established significantly better than wet plantings. Unfortunately, after the plots were planted, there was little rain. Plant development was poor and yields were low; 134 kgs. per hectare for millet and only 10.2 kgs. per hectare for sorghum.

Thinning was evaluated in two formats. As part of the double plowing trial, thinned strips were superimposed across the single and double plowed plots in order to standardize the post-establishment plant populations. This thinning resulted in a significant (though not large) yield benefit even though stands in the thinned plots were not significantly reduced. The result was largely attributable to the elimination of non-viable plants rather than a reduced overall population.

In a separate thinning trial, farmer group members (see Chapter VI) were asked to identify parts of their field where they felt the stands were too high. Thinning was targeted to areas where the plant response could be expected to be the greatest in order to maximize the potential returns to thinning labor and because women do not have the time to thin their entire field. Eight comparisons were implemented. The average time required for thinning was 39.5 hours per hectare. Measurements were made around six weeks after thinning on: live plants, heads, plants with less than six surviving leaves, and dead plants.

Unfortunately, most plots were not thinned enough or early enough. As a result, there was not sufficient compensation due to the lower population on the thinned plots (with respect to heads per plant or average head weight) to provide a reasonable return to labor invested in thinning. There were, however, some signs that proper thinning could increase the production potential of areas with extremely high initial establishments (and provide reasonable returns). A regression analysis of the trial results showed, for example, that for each additional 1,000 plants, the percentage of viable plants decreased by nearly two percent ($r = -0.89$) and the heads per plant decreased by 0.025 ($r = -0.56$).

D. BUDGET ANALYSES OF SELECTED PRACTICES

This section presents budget analyses of the most promising modified practices, including: (a) double plowing, (b) early plowing plus row planting, (c) sole planting of secondary crops, and (d) gap filling.

1. DOUBLE PLOWING

During the first three seasons of RM,FI trials, the average yield increase for double plowing was just greater than forty percent. In the 1985-86 FM,FI trials, there was a 94 percent yield increase due to double plowing. Double plowing also gave statistically significant benefits for grain yield in the RM,RI factorial trial.

a. RM,FI Trial Results

After the 1984-85 season, a partial budget analysis was carried out using the combined RM,FI trial results. Two specific issues were addressed:

1) Should a farmer double plow or single plow a given hectare? This issue is relevant to farmers who have a limited amount of land to plow or who are otherwise constrained in reaching production goals via planting greater area. It is also relevant to farmers who are able to do an early plowing at a time when they would otherwise be

unable to plant.

2) Should a farmer double plow a given hectare or single plow two hectares? This issue is relevant to farmers who are not land constrained, but may have limited weeding labor. The key trade-off to these farmers is the opportunity cost of the yield from the plot which might have been planted when early plowing was done. If farmers lack the labor resources to manage two plots, they might instead increase the inputs to a single plot, thereby by generating higher returns to the labor which is available, even if farm grain production is reduced somewhat.

The issues were analyzed through partial budgeting. Results are presented in Table 5.5. Each budget presents the expected changes in costs and benefits associated with the proposed shift to double plowing. The main costs and benefits are grain yields, labor time, and seed. The second part of each table presents a sensitive analysis of the basic budget taking into account different yields, resource use levels and/or resource valuation.

The analysis in the basic budget was oriented to traction owners since these farmers are the ones most likely to be able to implement double plowing. To the extent possible, resources were valued at their opportunity costs. In the case of labor, the government's Labor Based Drought Relief (LBDR) wage rate was used. There is no formal agricultural labor market in Botswana [Duggan, 1979] and the LBDR program provides the main opportunity for short term rural wage employment. Moreover, the LBDR wage is very close to the few reported observations on agricultural wage employment (for example, EFSAIP [1983]). For yields, local market prices were used. Local prices

TABLE 5.5: PARTIAL BUDGET: RM,FI DOUBLE PLOWING, 1983-84 AND 1984-85

	DP 1 HA VS SP 1 HA		DP 1 HA VS SP 2 HA	
BASIC BUDGET:				
Reduced Cost				
Seed Saving	-----		3.12/a	
Weeding Time Saving	3.57/b		12.46/c	
SP Harvesting Time/d	8.90		18.47	
Added Benefit				
DP Yield (198 kgs)	77.22		77.22	
Added Cost				
DP Second Plow/e	9.04		-----	
DP Harvesting Time	15.05		15.05	
Reduced Benefit				
SP1 Yield (126 kgs)	-----		49.14	
SP2 Yield (117 kgs)	45.63		45.63	
Net Gain		19.97		1.45
SENSITIVITY ANALYSIS:				
Yields from 1983-84 Trial Only/f		23.73		28.14
Yields from 1984-85 Trial Only/g		16.83		-27.43
No Weeding Time Saving		16.39		-11.01
Weeding Time Saving Plus 50%		21.75		7.69
Labor at Urban Minimum Wage (53t)		18.95		7.72
Grain Market Board Price (27t/kg)		10.25		5.89
Hired Traction (P50/ha)		-20.99		1.45

a. Seeding rate = 8 kg/ha. All grain valued at 39 t/kg.
b. Weeding times were not recorded. An imputed weeding time was calculated on the basis of plot monitoring data and data from EFSAIP. EFSAIP data show a 60% weeding time saving on double plow plots. The average weeding time by cooperators on plots weeded was 37.4 hours. Only 12 of the 19 trial plots were harvested. Assuming no gain in weeding time on plots not harvested, the calculated weeding time savings would be .63 x .4 x 37.4 = 9.4 hrs. All labor valued at 38 t/hr, the LBDR wage.
c. Weed times saving of 9.4 hours plus the 23.4 hours required for the second traditional plot. 23.4 hours is the time spent weeding, averaged across all plots.
d. Based on a standardized harvesting and threshing rate of 5 kg/hr. This is the average obtained from monitoring data [ATIP, 1986b].
e. The average plowing time for trial participants was 11.9 hrs/ha. Plowing labor was standardized to two people.
f. Yields were low: 53 kgs for SP1, 24 for SP2, and 117 for DP.
g. Higher yields: 271 for DP, 208 for SP1, and 200 for SP2.

represented a competitive equilibrium price, since trade in farm products is not regulated in Botswana.

Based on the 1983-85 trials, double plowing would have increased the value of production by more than 31 Pula and would have provided a net gain of nearly twenty Pula per hectare. The double plowing system required 30.6 more hours, so the return per extra hour invested would have been over one Pula per hour. Thus, double plowing provided an opportunity to work more hours during drought at an imputed wage which exceeded the urban minimum wage rate.

The sensitivity analysis showed that there would have been a net gain per hectare in both the 1983-84 and 1984-85 seasons, the first of which had very low yields while the second had relatively high yields for drought conditions. Valuation of labor using the urban wage rate had little effect on the profitability of double plowing. Use of the (low) BAMB price for sorghum reduced the net gain. An increased weeding savings would have increased the net gain.

The net gain from double plowing would have been lower for farmers substituting one hectare of double plowing for two hectares of single plowing. Due to the foregone yield from the second hectare, the net gain would have been only P1.45. However, forty fewer hours were required for the double plowing system, mostly due to fewer weeding hours. Thus, households facing a weeding labor constraint would have benefited from this system change. While farm grain production would have been reduced, farm system profitability would have been increased.

One drawback with the decision to double plow is a risk that the relative benefit might not hold up with better rains. A decision to substitute one double plowed hectare for two single plowed hectares would have resulted in a loss in the 1984-85 season, when higher yields were obtained for both single and double plowing.

In the two hectares versus one sensitivity analysis, valuing labor at the urban minimum wage rate increased the net gain for double plowing. Lack of a weeding saving resulted in a loss from double plowing, highlighting the importance of weeding benefits when assessing the value of double plowing.

The sensitivity analysis on traction hiring points out several crucial issues for draft-dependent households. The negative return from the first decision (1 ha DP instead of 1 ha SP) reflects the fact that neither system resulted in yields which were sufficient to justify an investment in tractor hire. Draft-dependent households would have been better off not plowing at all. Given the fact that crop failure, or near failure, is always a possibility in Botswana, the analysis suggests that hiring households should minimize their risk of loss by only plowing once.

However, the recommendation gets more complicated when one considers the second decision as well (1 ha DP instead of 2 ha DP). With this substitution, there would have been a net gain, and a reduction of labor requirements. The complications derives from the source of funds used for plowing. If the government were to give money only for plowing, or relatives sent remittances only for plowing, it would have been more profitable to invest that money in double plowing half as much land as could have been single plowed.

As with tractor owners, the second decision would have increased profitability and reduced labor requirements, but also reduced farm production. Which option is best for a hiring household, therefore, depends on a combination of labor availability, any restrictions the use of funds, and relative interest in profitability versus total farm production. On balance, it would not seem advisable to recommend double plowing to hiring households except on a special case basis.

b. FM,FI Trial Results

The same two questions were addressed in 1986 using results from the 1985-86 FM,FI double plowing trial. The partial budget analyses again showed there would have been a net gain from double plowing, as seen in Table 5.6. The net gain for double plowing any given hectare would have been slightly lower than for the 1983-85 RM,FI trials, but the net gain for substituting one hectare of double plowing for two hectares of single plowing would have been greater. When analyzed on a individual site basis, there would have been a positive gain for double plowing a given hectare at two-thirds of the sites. The decision to substitute one hectare of double plowing for two single plow hectares would have resulted in a net gain at 86 percent of the sites. Total production was almost as great from the one double plowed plot as two single plowed plots, but the total time invested was substantially less.

As before, it would not have been profitable for households hiring traction to invest in a (first or) second plowing on any amount of land. However, for any given amount spent on plowing, it would have been more profitable to double plow half as much land as could have been single plowed. Again, farm system profitability might not be the main issue in such a decision, since total farm grain production would decrease.

c. RM,RI Sensitivity Analysis

Table 5.6 also presents a sensitivity analysis based on the RM,RI trial results, so two additional issues can be addressed: application

TABLE 5.6: PARTIAL BUDGET: 1985-86 FM,FI
DOUBLE PLOWING TRIAL

	DP 1 HA VS 1 HA SP		DP 1 HA VS SP 2 HA	
BASIC BUDGET:				
Reduced Cost				
Seed Saving/a	-----		2.34	
Weeding Time Saving/b	1.41		8.93	
SP Harvesting Time /c	6.80		13.40	
Added Benefit				
DP Yield	67.74		67.74	
Added Cost				
DP Second Plow/d	11.71		-----	
DP Harvesting Time	13.20		13.20	
Reduced Benefit				
SP Yield	34.91		69.81	
Net Gain		16.13		9.40
SENSITIVITY ANALYSIS:				
Hired Traction/e		-22.16		9.40
RI Yields: All Sites				
No Phosphate		20.60		-85.99
With Phosphate/f		0.43		-97.66
RI Yields: Environment A/g				
No Phosphate		105.94		-34.56
With Phosphate		145.25		9.70

a. Seeding rate = 6 kg/ha. All grain valued at 39 t/kg.
b. Average weeding times were 19.8 hrs/ha for SP and 16.1 for DP. All labor valued at 38 t/hr (the LBDR wage rate).
c. Based on harvesting and threshing rate of 5 kg/hr.
d. Standardized to donkey plowing with two workers. Average donkey plowing time was 15.4 hr/ha.
e. Substitutes the standard plowing hire rate in Central Region for the plowing labor charge.
f. Phosphate budget includes: (a) labor charge for two hours to haul bags and broadcast, and (b) a P62.89 charge for 3.8 bags of SSP at P16.55 per bag. The without P or DP yields are compared to the with P and DP yields.
g. Environment A has deep to moderately deep soils with high total water holding capacity and with a rainfall pattern favorable for response to early tillage (i.e., good pre-planting rain with dry conditions immediately following).

of phosphate and site selection. The analysis assumes that the relative weeding times would have been the same for the RM,RI trial as were observed for the FM, FI trial. The reasonableness of this assumption cannot be proven. Harvest times for all the partial budgets were based on a standardized ratio of time per unit harvest, since harvesting times are only affected by tillage treatments via the effects of the treatments on yields.

Based on yields achieved in the RM,RI trial, there would have been a net gain (for traction owners) from substituting double plowing for single plowing, but only if land was a constraint. Otherwise, it would have been better to keep single plowing additional hectares. This result was due to the relatively better yields achieved with single plowing when single plowing was researcher managed and implemented.

The analysis using RM,RI trial shows that the profitability of double plowing is quite sensitive to the soil and rainfall environment in which double plowing is implemented. In Environment A, that most conducive to a double plowing benefit, the net gain per hectare would have exceeded P105. Even in Environment A though, it would have been more profitable to single plow two hectares than it would have been to double plow a single hectare, if land and weeding labor were available.

Averaged across all sites, the combination of phosphate and double plowing would have been even less profitable than double plowing alone. However, in the proper environment, there was a synergistic effect between double plowing and phosphate, which would have made the application of phosphate profitable. With phosphate application, the decision to double plow would have been profitable in Environment A even if traction had been hired.

2. EARLY PLOWING PLUS ROW PLANTING

The yield increases obtained from row planting in the RM,FI tillage-planting systems trials during the first three seasons were almost identical to those from double plowing. Row planting yields often were higher in the RM,RI trials than with double plowing, and row planting has a smaller draft requirement than does double plowing.

a. The Decision to Row Plant

Following the 1985 season, two issues were addressed for row planting, which are analogous to those raised for double plowing:

1) Should a farmer early plow and row plant rather than broadcast and plow a hectare? This issue is relevant to farmers who own row planters but do not use them even though they have a limited amount of land or can plow when there is too little moisture to plant. The issue could be of some importance in the Central Region where many farmers who own row planters use them infrequently.
2) Should a farmer early plow and row plant one hectare rather than broadcast and plow two hectares? This issue is most relevant to farmers who have the land, but not the labor resources to support an extensive orientation toward farm production (but do own a row planter).

The results of partial budget analyses of these questions are summarized in Table 5.7. The results are quite similar to those for double plowing. For each hectare farmers early plowed and row planted they would have gained over P21, relative to the traditional broadcast-single plow approach. The return per extra hour invested would have been above one Pula. The net gain and returns to labor would have increased even more if farmers would have weeded using a

TABLE 5.7: PARTIAL BUDGET: EARLY PLOW AND ROW PLANT, 1983-84 AND 1984-85

	RP 1 HA VS BP 1 HA		RP 1 HA VS BP 2 HA	
BASIC BUDGET				
Reduced Cost				
Seed Saving/a	0.78		3.90	
Plow 2nd BP plot	----		9.04/b	
Weeding 2nd BP Plot	----		8.89	
BP Harvesting Time/c	8.90		18.47	
Added Benefit				
RP Yield (201 kgs)	78.39		78.39	
Added Cost				
Hours Row Planting/d	6.08		6.08	
RP Harvesting Time	15.28		15.28	
Reduced Benefit				
SP1 Yield (126 kgs)	-----		49.14	
SP2 Yield (117 kgs)	45.63		45.63	
Net Gain		21.08		2.56
SENSITIVITY ANALYSIS				
Yields from 1983-84 Trial Only		19.67		24.23
Yields from 1984-85 Trial Only		22.49		-21.92
Saving from Cultivator Weeding/e		28.03		9.51
Labor at Urban Minimum Wage (53t)		16.16		8.50
Grain Market Board Price (27t/kg)		10.76		6.40
Hired Traction (P50 plow; P25 plant)		2.16		24.60

a. Row plant seeding rate = 6 kg/ha. Broadcast seeding rate = 8 kg/ha. All grain valued at 39 t/kg.

b. Plowing rate of 11.9 hr/ha (timed rate, some used double furrow plows). Standardized to two people plowing. All labor valued at P0.38/hr.

c. Based on harvesting and threshing rate of 5 kg/hr.

d. Row plant rate of 8 hr/ha with two people planting.

e. Saving from cultivator weeding of 18.3 hrs/ha. This is the difference between an average weeding time of 37.4 hrs/ha on hand weeded plots (obtained from plot monitoring) and the average cultivating time of 8.4 hrs/ha (measured trial data). The difference, 29 hrs. is multiplied by .63, since only 12 of 19 plots were harvested. Farmers usually do not weed plots which are abandoned before harvesting.

f. Low yields: 104 for RP, 53 for BP1, and 24 for BP2.

g. Higher yields: 288 for RP, 208 for BP1, and 200 for BP2.

cultivator. Both a higher opportunity cost for labor and a lower price for output reduced the net gain in the one hectare versus one hectare decision. Unlike double plowing, however, early plowing and row planting would have been a better option than broadcasting even if traction had to have been hired for both the plowing and row planting operations.

There would have been a slight net gain for the decision to substitute one row planted hectare for two double plowed hectares. The value of production would have decreased by over P16, but the value of the labor saved would have been even greater, increasing farm system profitability. However, a net gain would have been achieved in only one of the two seasons, the one with worse rains and lower yields. This suggests that the relative advantages of intensification are less in good seasons. This could be a major reason farmers have not been more responsive to the extension recommendation to row plant.

In the sensitivity analysis for the one row planted hectare versus two broadcasted hectares, a higher opportunity cost for labor or lower value for output increased profitability relative to the basic budget. Row planting should be particularly attractive for hiring households, assuming of course they can find people who will row plant at the rate of P25 per hectare.

b. The Decision to Buy a Planter

Because row planting involves a new implement for most farmers, an additional question was addressed: should a farmer who does not own a row planter buy one, given the row planting trial results (obtained during drought seasons)?

The decision to invest in a row planter was addressed using capital budgeting and the net gain from Table 5.7. The basic budget assumed a ten year life for the planter, that the planter could be used for two hectares each year without a reduction in the average area planted, and a discount rate of ten percent. Sensitivity analysis took into account different discount rates, numbers of hectares row planted each year, and acquisition costs.

Results on the benefit-cost ratio, the net present worth, the internal rate of return, and the "break-even net gain" are summarized in Table 5.8. One would ordinarily make an investment if the benefit-cost ratio is above one or the net present worth of the investment is greater than zero. The internal rate of return represents the average annual rate of return to the capital invested in the row planter. This rate of return can be compared to the opportunity cost of alternative capital investments. The "break-even net gain" is the threshold level of net gain required for the benefit-cost ratio to equal one (or the net present worth to be zero).

The basic capital budget analysis indicated that farmers who did not own a row planter should not have bought one. However, the sensitivity analysis showed that several factors could have made the investment profitable. For example, any farmer obtaining a higher than average net gain per hectare (for example, through site selection or learning how to row plant better) or row planting more hectares each season, could have profited from investing in a row planter.

Most significantly, a farmer would have had to obtain a net gain of only P6.15 per hectare in order to have profitably invested in a row planter--if the row planter was purchased through ALDEP. Under the 85 percent ALDEP subsidy, the benefit-cost ratio for a row planter

TABLE 5.8: INVESTMENT IN A ROW PLANTER: BENEFIT-COST RATIO, NET PRESENT WORTH, INTERNAL RATE OF RETURN

ASSUMPTIONS:			
Discount rate:	0.10	Net gain per hectare:	21.08/b
Initial cost:	350.00/a	Hectares RP per year:	2
Years:	10	Maintenance per year:	9.85/c

	BENEFIT -COST	NET PRESENT WORTH	I.R.R.	BREAK-EVEN GAIN
BASIC BUDGET/a	0.69	-115.42	-18.8	30.48
SENSITIVITY ANALYSIS:				
Discount Rate:				
0%	0.94	-26.90	----	22.43
5%	0.80	-80.67	----	26.31
15%	0.61	-137.48	----	34.83
Hectares RP:				
3	1.04	14.11	11.3	20.32
5	1.73	273.17	35.4	12.19
Cost:				
85% Subsidy/d	3.43	187.57	119.0	6.15
50% Subsidy	1.30	60.46	20.4	16.17

a. Average cost of single row planter in Mahalapye area.
b. Based on Table 5.7.
c. Maintenance charges assume P25.00 in set-up cash costs plus cash maintenance costs equal to 1% of the original cost per year beginning in year 5 and increasing each year following by 1% per year. Higher maintenance costs would be inconsistent with observed practices, particularly under the assumed usage rate of only 2 hectares per year.
d. The current ALDEP subsidy.

investment would have been 3.4. Even with only a 50 percent subsidy the benefit-cost ratio would have been 1.36.

3. SOLE PLANTING OF SECONDARY CROPS

During three seasons in which broadcasted secondary crops were compared in both an RM,FI and FM,FI format, yields were low. However, because of their high value during drought, it may still be advantageous to sole plant secondary crops.

Following the third season, yield data from the cropping comparison and the cowpea planting methods-variety trials were used to make a preliminary assessment whether farmers who do not currently plant small plots of secondary crops in sole stands might benefit from doing so. The analysis was based on a comparison of the net value of production per hectare (yield minus the amount of seed planted) for sorghum and the main secondary crops. (Because of the original trial objectives and the small plot sizes, no attempt was made to record labor data, so returns to labor could not be calculated.) Sorghum yields were based on findings from the MVRU Survey.

The value of minor crops (eg. sweetreed and melons) normally present in sorghum mixtures was not included in the analysis since it was assumed that all requirements for these crops could still be met if only a small portion of land was diverted to sole planted cowpeas, groundnuts, mung bean or tepary bean. Similarly, the value of the morogo (spinach) from the sole planted cowpea plots was not included since it was assumed that the normal crop mixtures of farmers satisfy the demand for morogo. Two sets of prices were used to value the grain produced. The first set was based on results from the 1985 Trader Baseline Survey. These prices had a large gap between the value of sorghum and the various secondary crops. The second set was the BAMB prices for Mahalapye. BAMB price differentials were much smaller.

The results of the analysis are presented in Table 5.9. Although widely varying yield results were obtained during the two seasons, essentially all the secondary crops gave a higher net value of production than did sorghum. The value of production was less only for ER-7 cowpeas in the 1983-84 season when using BAMB prices. In general, groundnuts and ER-7 cowpeas returned the lowest value of production, despite the high prices received for groundnuts. In two of the three trials, Tswana cowpeas gave the highest value of production per hectare. Tswana cowpea plants also provided the most (unvalued) morogo.

It is not possible to draw definite conclusions based on a "value of production" analysis. Despite the higher values of production for the secondary crops relative to sorghum, the net margin may not have been higher since labor requirements tend to be higher on secondary crops. For example, harvesting cowpeas and mung beans often takes longer than does harvesting sorghum. Groundnuts and jugo beans traditionally are "hilled" to facilitate pegging. Nevertheless, the results presented in Table 5.9 suggest that sole plantings of secondary crops would have generated returns to both land and labor which would have exceeded those from sorghum. This is reflected in the fact that the gross values of secondary crops produced per unit area were several hundred percent higher than for sorghum (when using local market prices). Labor requirements for secondary crops are not that much higher than for sorghum.

In the 1985-86 season, sole cropping of secondary crops was evaluated in an FM,FI framework, and labor data were collected. An

TABLE 5.9: GROSS VALUES OF PRODUCTION FOR SECONDARY CROPS AND SORGHUM, 1983-84 AND 1984-85

		PRICES		GROSS VALUE/c	
	YIELD/a	P1/b	P2	P1	P2
1983-84 SEASON					
Sorghum/d	74	.39	.26	26.44	16.64
Cowpeas:					
Tswana	144	1.56	.35	209.04	46.90
Blackeye	141	1.56	.47	204.36	61.57
ER-7	27	1.56	.39	26.52	6.63
1984-85 SEASON					
Sorghum	35	.39	.26	11.23	6.50
Cowpeas (1)/e:					
Tswana	52	1.56	.35	65.52	14.70
Blackeye	76	1.56	.47	102.96	31.02
ER-7	58	1.56	.39	74.88	18.72
Sri Lanka	168	1.56	.39	246.48	61.62
Cowpeas (2):					
Tswana	175	1.56	.35	257.40	57.75
Blackeye	116	1.56	.47	165.36	49.82
ER-7	112	1.56	.39	159.12	39.78
Sri Lanka	127	1.56	.39	182.52	45.63
Groundnuts	21	2.00	.89	26.00	11.57
Mung Bean	114	1.56	.41	170.04	44.69
Tepary Bean	79	1.56	.41	115.44	30.34

a. All yields are threshed kilograms per hectare.
b. P1 = prices from 1984 Trader Survey. P2 = 1986 BAMB prices for Mahalapye.
c. The value of grain produced minus the value of seed.
d. Average yields for cooperators.
e. Cowpeas (1) = Cropping Comparison Trial. Cowpeas (2) = Planting Methods - Variety Trial.

enterprise analysis of the sole planted plots was carried out in 1986. Results from the analysis are presented in Table 5.10.

For farmers who were able to plow using their own animals, the returns to labor exceeded the LBDR wage for four of the six crops. For purposes of comparison, the approximate value of sorghum production per hectare for the farmers implementing the trial (based on total farm production divided by the hectares planted) was only P6.05, less on a per hectare basis than all secondary crops except maize. Jugo beans was the most profitable crop, giving a value of production per hectare of more than P100, and a net margin of over P54, nearly twice as high as the next most profitable secondary crop. The biggest constraint on expanded jugo bean production is seed availability.

If hired traction had been used, the net margin per hectare would have been negative for all crops except jugo beans, even when using local prices (high for output and low for labor). However, the loss would have been even greater if the entire field would have been planted to sorghum.

At the end of the season, farmers were asked to compare their experiences in growing the crops sole versus in mixed planting. Every farmer said that the problems encountered in growing crops sole were no more severe or were less severe than when crops are mixed. Most farmers further noted some advantages in growing sole plantings, particularly with respect to the timing of planting, site selection, and harvesting labor.

4. HAND PLANTING FOR GAP FILLING

Hand planting was first examined during the 1984-85 season, in relation to secondary crops establishment. Hand planting did not

TABLE 5.10: SOLE CROPPING TRIAL: ENTERPRISE ANALYSIS, 1985-86

	JUGO BEAN	MUNG BEAN	SRI LANKA	ER-7	KEP MAIZE	SELLIE GN
NUMBER OF PLOTS	15	16	20	27	26	10
INPUTS:						
Seed (gms)	750	333	500	500	1000	1125
Area (sq m)	930	499	867	750	894	795
Seeding rate (kg/ha)	8.1	13.4	5.8	6.7	11.2	14.2
Traction used (% plots):						
Donkeys	27	47	42	58	56	20
Cattle	20	13	5	15	16	10
Tractors	53	40	53	27	28	70
Plowing depth (cms)	13	14	13	14	14	13
Plowing time (hr/ha)/a	7.5	10.0	9.8	11.3	10.9	7.3
Weeding time (hr/ha):						
All plots	33.0	2.5	14.1	3.6	2.6	29.0
Weeded plots	49.2	12.4	20.0	8.6	9.1	57.9
Harvesting time (hr/ha):						
All plots	27.8	4.9	23.1	20.3	0.4	23.8
Harvested plots	33.3	18.4	36.6	43.9	10.0	29.7
Threshing time (hr/ha):/b						
All plots	6.9	0.3	2.9	1.8	0.1	5.1
Harvested plots	8.3	1.2	4.5	3.9	2.6	7.1
OUTCOMES:						
Stand establishment (plants/ha x 1000)	14.4	5.7	10.2	19.0	3.4	21.7
Pct. plots weeded	73	19	75	41	27	70
Pct. plots harvested	67	27	63	46	4	71
Yield (kgs/ha):						
All plots	48.3	4.6	40.1	25.0	3.5	35.6
Harvested plots	58.0	17.2	63.5	54.2	90.4	49.9

(continued next page)

TABLE 5.10 (continued)

	JUGO BEAN	MUNG BEAN	SRI LANKA	ER-7	KEP MAIZE	SELLIE GN
VALUE OF OUTPUT/c:	108.68	7.18	62.56	39.00	2.10	71.20
VARIABLE COSTS (P/ha):						
Seed	18.23	20.90	9.05	10.45	6.72	28.40
Plowing:						
Own Donkeys/d	11.70	11.70	11.70	11.70	11.70	
Hired Tractor/e	50.00	50.00	50.00	50.00	50.00	50.00
Post-plant labor/f	25.73	2.93	15.24	9.77	1.18	22.00
GROSS MARGIN:						
Per hectare:						
Own Donkeys	53.02	-28.35	26.57	7.08	-17.50	9.10
Hired Tractor	14.72	-66.65	-11.73	-31.22	-55.80	-29.20
Per hour:						
Own Donkeys	0.92	-0.36	0.75	0.51	-0.14	0.48
Hired Tractor	0.60	-8.28	0.09	-0.83	-17.62	-0.12

a. Plowing rates, regardless of crop sown, were 15.4 hr/ha for donkeys and 3.8 hr/hr for tractors. Few oxen plowing times were recorded.

b. Based on threshing rates of 14 kg/hr for cowpeas and mung bean and 7 kg/hr for groundnuts, jugo beans, and maize.

c. Prices used were: jugo beans, 2.25; mung bean, Sri Lanka and ER-7, 1.56; KEP, .60; groundnuts, 2.00.

d. Plowing labor standardized to two workers.

e. Standard tractor hire rate in Central Region.

f. All labor valued at the LBDR wage, P0.38/hr.

outperform broadcast planting but, in the context of a gap filling strategy, this is not the relevant analysis. When considering gap filling, plowing and weeding inputs must be treated as unvalued sunk costs. The key issue is the return to hand planting and harvesting labor, after deducting a charge for the seed.

In the 1984-85 cowpeas planting methods-variety trial, yields averaged from 112 to 175 kgs. per hectare. At local prices, this would have provided a return to the hand planting and harvesting labor of around two Pulas per hour (more than three times the urban minimum wage). Even if one were to include a charge for weeding at a rate of 30 hours per hectare, the returns to gap filling labor would have been more than double the urban wage rate.

In the 1985-86 season, hand planting for gap filling was examined for sorghum and millet. Due to late planting and post-planting drought, yields were low. Despite the low yields, the average returns to labor across all sites were P2.18 per hour for millet and P0.27 for sorghum (taking into account planting and harvesting labor and the value of seed). Even if an additional 30 hours per hectare of weeding had been required, the return per labor hour for gap filling, weeding and harvesting the millet still would have been P0.96.

E. CONCLUSIONS AND RECOMMENDATIONS

This chapter has: (a) given an overview of cropping outcomes during drought, (b) reviewed efforts to identify improved production practices, and (c) presented budget analyses of a few promising interventions for production during drought. This section presents conclusions and recommendations on promising production practices.

1. CROPPING OUTCOMES

The research revealed a "normal" pattern of poor cropping outcomes, which was aggravated due to drought conditions. In each season, a large proportion of the area planted was neither weeded nor harvested.

Despite the drought, some real income was generated by draft controlling households. For example, the value of crops production above variable costs in the 1984-85 season was equivalent to the cost of 450 kgs. of store bought maize. On a per hour basis, the gross margin was only P0.26. This is less than half the urban minimum wage rate and only 70 percent of the LBDR village wage. The returns were insufficient to cover traction hire fees. Nevertheless, for traction owners, the returns were equivalent to those women earn in beer brewing and selling [ATIP, 1986].

Two elements of the traditional system were responsible for what little success was achieved. First, the non-grain component of production was substantial. Second, farmers wisely cut back on their labor inputs as expected crop outcomes were revised downward in the face of the unfolding drought year.

Significant and consistent differences were identified in cropping outcomes by household type, both with reference to "normal" outcomes and the outcomes observed during the drought seasons. Male headed, cattle rich and draft controlling households plowed more days, achieved higher production levels and (at least during drought) had higher yields.

The findings on cropping outcomes reinforce several conclusions from Chapter III and IV, including: (a) the value of secondary and minor crops, (b) the need for interventions for all households not just poor households, (c) the significance of the trend toward tractor hire and ownership, and (d) the need to keep capital investments to a minimum

2. THE RECORD OF TECHNICAL EXPERIMENTATION

In 1982, the bottom line on technical experimentation in Botswana was that few answers had been developed relative to the resources invested. Building on this "state of knowledge," on-farm research in the Central Region initially focused on a comparison of planting methods. Before long, the scope of investigations expanded to include several types of tillage-planting systems, secondary crop and variety selection, sole cropping, and post-establishment stand management practices.

After four seasons of research, the results of the various investigations could be divided into four categories.

a. No actual or potential benefits were identified for: plow-planters (particularly when mounted on single furrow plows), harrowing (particularly as a weed control tillage), ridge plows, ridge planters, strip tillage systems, manuring or draft animal feeding.

b. Not enough trials were successfully conducted to reliably assess the potential benefits of (or work out problems with): seed treatments, hand furrow planting, the advantages of replanting versus relying on an existing poor stand, undersowing, the relative advantages of different tillage-weed control systems for row planting, early weeding versus standard weeding, or compound garden plots.

c. There were promising indications, but no firm conclusions, for: thinning, sub-soiling, multiple purpose uses of cultivators (pre-plant weed control or to incorporate broadcasted seed), phosphate applications on certain soil types, and site selection for double plowing.

d. There was some confidence that farmers could obtain at least small improvements by double plowing and/or early plowing followed by row planting, production of sole planted secondary crops, and gap filling.

3. PROFITABLE PRODUCTION PRACTICES FOR DROUGHT CONDITIONS

The partial budget analyses showed that traction owners could benefit from a shift to double plowing, and could even benefit slightly if half as much area had to be plowed in total in order to double plow. Similar results were obtained for early plowing plus row planting. The benefits from either system, however, were not great and may not stimulate much farmer interest. Both systems were viable alternatives for farmers facing either land or labor constraints.

The benefits of a second plowing were not great enough to pay for a second hiring of a tractor, so double plowing cannot be recommended as a strategy for draft-dependent households. This result stems from the general unprofitability of arable farming during drought.

When comparing row planting and double plowing, it is hard to choose based on the budget analyses. Row planting, of course, requires an additional implement but most farmers can obtain a planter at 15 percent of its cost. Several less tangible factors support a relatively greater emphasis on row planting as a long run strategy, including: (a) eventual elimination of the weeding labor constraint through inter-row cultivation, (b) better control over seed depth placement and plant spacing, (c) greater stability over a range of soil environments [ATIP, 1986], (d) smaller draft requirements if plowing is hired and planting is done with two donkeys, and (e) flexibility in replanting. Therefore, the challenge of solving the problems constraining the spread of row planting should be the top priority of both research and extension in the Central Region (particularly with reference to the draft-controlling research domain). Such a priority would be consistent with farmers' interest in row planting.

The budget analyses of secondary crops provided evidence that the returns were as high or higher than for sorghum. On balance, it would appear that small plots of sole planted secondary crops should be recommended. However, maize should be actively discouraged. Jugo beans and dual purpose cowpeas (intermediate plants such as Sri Lanka and Blackeye) would seem to be the best secondary crops to promote. There would not appear to be any need to recommend special planting methods for the secondary crops.

Based on two drought seasons in which poor yields were obtained, hand planting for gap filling provided returns to the additional labor invested that exceeded urban minimum wages and were four times the average return to crop production labor. Hand planting for gap filling would appear to be a viable option to promote, particularly to farmers lacking control of traction resources.

VI. AGRICULTURAL SUPPORT SYSTEMS AFFECTING ARABLE FARMING

This chapter presents findings from research on: agricultural extension, the trading network, village groups, and participation in ALDEP and Drought Relief. The objectives are to: (a) analyze the performance of selected agricultural support systems, and (b) identify policy and institutional options to improve their performance.

A. AGRICULTURAL EXTENSION

Agricultural Demonstrators (ADs) are the link between farmers and the Ministry of Agriculture. All messages about modified production practices and assistance programs are channeled through ADs. The Department of Agricultural Field Services uses the ADs' annual reports to determine extension service priorities. Therefore, any institutional changes which improve the effectiveness of ADs in communicating messages, demonstrating innovations, and providing feedback to the Ministry should eventually contribute to arable farming development.

To identify opportunities for improvement, the activities and problems of ADs in the Central Region were investigated in a 1983 regional survey. The survey had two objectives. The first was to determine the extent to which farming systems differ across the Central Region. The second was to find out what ADs do, what they believe to be important, and what problems constrain their effectiveness.

This section begins with a brief historical perspective on extension in Botswana. The second part summarizes the results of the

1983 regional survey.

1. HISTORICAL PERSPECTIVE OF EXTENSION IN BOTSWANA

The primary mandate of the extension service through the 1950s was to provide advice on methods. There was no mandate to offer services to farmers. The main activity of extension workers was to carry out demonstrations on farmers' fields. The relative emphasis on providing advice versus services has completely changed.

In 1962, the Pupil Farmer Scheme was established as the primary mode of agricultural extension. In this approach, each AD concentrated on improving the practices of about 25 farmers. In order to qualify for the scheme, a farmer had to own a plow and draft oxen, and needed destumped land. As their farming methods improved, pupil farmers were promoted through "progressive" and "improved" stages, until they became a "master farmer." In the end, master farmers autumn plowed, row planted in early spring using appropriate spacing, used quick-maturing varieties, did regular weeding, applied fertilizer as needed, followed a defined crop rotation, and used contour bunds (if needed) [ESM, 1965].

During the early 1970s, three major consultancies were commissioned to examine the Pupil Farmer Scheme and the organization of the extension service [Willett, 1981]. Each of the consultancies proposed abandonment of the Pupil Farmer Scheme. The consultants argued that, even though the pupil farmers did become more productive, the recommended technologies rarely spread to other farmers. Most other farmers lacked the necessary resources [Lever, 1970; Willett, 1981] and ADs often were too busy with their pupils to spend time with other farmers. Lever [1970] reported that ADs spent approximately 90 percent of their time with the pupil farmers.

The consultants identified several major problems in the administration and management of the extension service. For example, agricultural extension activities were being carried out by several sections of the Ministry of Agriculture, leading to overlap and confusion. In addition, field staff were inadequately supervised, poorly housed, lacked necessary extension equipment, and were short of suitable transport.

Both the extension approach and the organization of extension activities were changed in the mid-1970s to their current status. In 1973, a principle of pursuing both group and individual extension was adopted. In 1976, the Pupil Farmer Scheme was ended. ADs now are required to work with groups of farmers whenever possible. Different approaches are used for communicating extension messages, including demonstrations, speaking at village meetings and participating in village groups.

Following the consultants' advice, the Ministry of Agriculture was reorganized during 1974 and 1975. A regional administrative structure was established for the extension service. To improve field staff management, several institutional changes were introduced, including: (a) farmer record cards, (b) monthly management meetings involving all the ADs for each extension district, (c) monthly and annual plans for each AD, and (d) a daily activities planning and record system.

One of the key issues facing the Ministry in the 1980s is whether the reorganization of the extension service and the adoption of a group extension approach have accomplished the envisioned aims.

2. EXTENSION IN THE CENTRAL REGION

Fifty-two out of 54 ADs then stationed in the Central Region participated in the 1983 Agricultural Demonstrator Survey. Of the 52 respondents, approximately ten came from each of the five extension districts. (A sixth district, Letlhakane, was later added to the region). All but four ADs were male, with no district having more than one female AD. On average, the ADs had completed their formal education ten years prior to the survey but each had attended an in-service training course within the previous two years. In terms of formal education, only a third had attended the equivalent of high school, approximately 40 percent stopped with the equivalent of a junior high school degree, and 30 had less than a junior high school degree. All ADs had technical agricultural certificates, mostly from the BAC.

a. Extension Area Characteristics

An overview of extension area characteristics is presented in Table 6.1. On average, extension areas encompassed two or more villages and more than 400 farming families. Lands areas were on average between six and twenty-four kilometers from the villages where ADs were stationed. Sorghum, maize and cowpeas were the most important crops in every district.

Donkey traction was used by 25 percent of households, higher than the national average. Donkey traction was particularly important in Mahalapye East and Bobonong. Tractors or tractors in conjunction with animal traction were used by 36 percent of the households.

In all areas, there was little use of progressive practices. For example, an average of less than 30 households per area did more than one weeding, less than 20 households used row planting, and even fewer

TABLE 6.1: EXTENSION AREA CHARACTERISTICS BY DISTRICT

	MAHALAPYE WEST	MAHALAPYE EAST	PALAPYE	SEROWE	BOBONONG	ALL
SIZE OF EXTENSION AREAS:						
Villages	1.1	2.6	3	3.3	2.5	2.5
Farming families	353	283	640/a	523	368	433
Nearest Lands (kms)	6	4	5	7	7	6
Farthest Lands	16	23	23	32	28	24
MOST IMPORTANT CROPS:						
First/b	Sorghum	Sorghum	Sorghum	Sorghum	Sorghum	Sorghum
Second	Maize	Maize	Maize	Maize	Maize	Maize
Third	Cowpeas	Cowpeas	Cowpeas	Cowpeas	Cowpeas	Cowpeas
Fourth	Jugo Bean	Jugo Bean	Jugo Bean	Millet	Millet	Millet
FIELDS:						
Size ("acres")	12	16	12	17	18	15
Households with:(%)						
Wire Fencing	22	54	14	17	48	30
Bush Fencing	44	27	30	23	41	32
No Fencing	34	19	56	60	19	38
PRIMARY TRACTION (% HH):						
Donkeys	16	36	11	10	60	25
Cattle	47	35	47	49	12	39
Tractors	13	7	12	23	10	13
Tractors & Animals	24	22	30	18	18	23
PCT. HH HIRE TRACTION	34	33	24	25	26	29

Source: 1983 Agricultural Demonstrator Survey.

a. Based on 9 of 10 ADs. The other AD could not estimate the number of farming families.

b. Rankings derived from inverse weighting of subjective appraisals by ADs.

households applied fertilizer, did winter or spring plowing, use a metal harrow, used fallow in rotation, or had cut and stored fodder.

In total, more 50 characteristics were recorded for each extension area. When extension area characteristics were analyzed by district, few significant differences were identified. The most important difference was the importance donkey traction in the Bobonong and Mahalapye East Districts, versus the importance of cattle and tractor traction in the other three districts. Otherwise, the variability among areas within districts was greater than differences across districts. Also, there was a general homogeneity of farming problems and practices in the Central Region.

The survey did reveal important differences between extension areas when compared on an individual basis. For example, row planting was dominant in one extension areas, but in no other extension area. Similarly, there were differences in the amount of wire fencing, the distance to the lands, and the percent of households owning cattle.

b. Extension Activities

ADs provided advice and services to farmers, acting as field agents for several government programs. Advice was provided through direct contacts and at village meetings. Village meetings were the primary forum for contacting farmers. On average, village meetings were addressed ten times during the cropping season, more frequently in Mahalapye East and Serowe Districts than elsewhere. The emphasis of AD messages at village meetings was on government programs, particularly ALDEP, rather than promotion of improved technologies. Group formation and drift fencing projects were priority topics in every district.

According to the ADs own estimates, only one-fifth of the farming families were contacted even once a season. Only one in fifteen farmers was contacted once per week, and these farmers often were the same ones week after week. When ADs were asked what distinguished the farmers contacted regularly, 85 percent of the responses related to attitudes, productivity, and resources that would be associated with the best, most progressive farmers. This raises the issue as to whether abandonment of the Pupil Farmer Scheme increased the amount of extension advice being received by poorer, less progressive farmers.

In providing advice to farmers, ADs stressed the same recommended practices throughout the Central Region, almost in the exact same order of importance. Row planting was the main recommendation in each district, followed by early plowing, crop rotation and early weeding. There clearly was more unanimity among ADs on what farmers should be doing than there is among DAR personnel.

In addition to providing advice, ADs were responsible for demonstration plots and for supplementing supplies of equipment, seed, and fertilizer. During the 1982-83 season, few demonstrations were attempted and very few were successfully implemented. The number of demonstrations ranged from just over one per area in Bobonong District to three per area in Serowe District, averaging two per area across the region. Eighty-seven percent of the demonstrations dealt with row planting and/or fertilization (including manuring). The main types of equipment provided were planters, cultivators, harrows, burdizzos (an implement for castrating) and dehorning irons. A summary of equipment supplies is given in Table 6.2. As can be seen, few farmers made use of AD planters, cultivators or harrows.

Just over sixty percent of the ADs reported sales of sorghum and

TABLE 6.2: AD SUPPLY AND USE OF EQUIPMENT, 1983

	NUMBER AVAILABLE	NUMBER OF FARMERS USING TOTAL	PER PIECE
PLANTERS	1.7	6.0	3.5
	(1.5) a	(9.1)	
CULTIVATORS	0.9	3.1	3.4
	(1.4)	(8.2)	
HARROWS	0.8	5.0	6.2
	(0.9)	(7.9)	
BURDIZZOS	0.4	67.3	156.5
	(0.6)	(196.1)	
DEHORNING IRONS	0.8	55.0	70.5
	(1.7)	(192.8)	

Source: 1983 Agricultural Demonstrator Survey.
a. Standard deviations in parentheses.

maize seed. Nearly all the ADs reported they could have sold more seed had it been available. Forty-two percent provided fertilizer but the number of farmers receiving fertilizer was quite small (3.6 per area where any fertilizer was provided). The remaining major activity of ADs was helping with ALDEP applications.

An analysis of correlations among farmer contact activities showed there were positive and significant (above .9 confidence level) correlations of .35 to .40 between times addressing a village meeting, families met individually during a season, and the number of demonstrations. There also was a positive (.34) and significant correlation between the number of record cards kept and the number of families met during a season. Each of these activities were negatively related to the number of visits to the lands area per week (but not significantly so). It would appear that certain ADs are more active and this is reflected in all their farmer contact activities, except for visits to the lands areas. Visits to the lands areas may be a substitute for other types of farmer contact activities.

c. Institutional Support

Monthly management meetings are the main format for giving instructions to ADs and helping them with problems they encounter. Eighty-eight percent of ADs said they had reported problems to a monthly management meeting during the six months preceding the survey. Eighty-two percent said they felt monthly management meetings were useful. The main value of the meetings was seen as the opportunity to interact and get ideas. Among the eighteen percent who were dissatisfied, the primary concern was that complaints and problems were never solved.

In addition to the monthly management meetings, sixty percent of the ADs had requested special assistance at some time in the two years preceding the survey. The proportion of ADs requesting assistance ranged from a low of 30 percent in Mahalapye East to 75 percent in Bobonong. On average, just over four requests were made during that two year period by those ADs who made any requests. (The median number of requests was lower since a few ADs made more than 20 requests.)

The most frequently contacted person was the District Agricultural Officer. The DAO and the Regional Crop Production Officer were the main individuals providing information directly to ADs. Less than half the ADs requesting help felt they received timely and effective help. Twenty-five percent reported they received no help and 25 percent said they received help, but it arrived too late to be of use.

There was a clear consensus among ADs that closer ties were needed between researchers, extension agents and farmers. For example, ninety percent said there should be more village research and eighty-one percent agreed when asked if researchers and ADs should try to learn from farmers. Only 31 percent felt they knew what was going on in Sebele research.

d. Perceptions and Priorities

ADs were asked about the value of different crops and practices in order to assess perceptions affecting AD behavior. A summary of responses is given in Table 6.3. Nearly all ADs said that sorghum was the most valuable crop because it is harvested in large quantities, and has multiple uses and a relatively stable yield. Multiple uses also was mentioned as an attractive feature of cowpeas (harvesting leaves in bad years) and melons. High demand and/or prices was mentioned for five of six of the most valuable crops. ADs said early maturity (availability of product) was a valuable feature of cowpeas, maize and melons.

Table 6.4 summarizes ADs' views on changes farmers could make to increase productivity, why each change would increase productivity, and why farmers do not make the change. Row planting was by far the highest ranked change, followed by fertilizer use, fencing, winter or spring plowing and early planting. In general, the reasons ADs cited for productivity increases were obvious and somewhat superficial. It was not clear from the survey that the ADs had a good understanding of the advantages and problems of different production practices. Lack of a proven benefit, or other technical questions, were only cited as major problems for fertilizer use, better weed control and early planting. Otherwise, the ADs tended to cite resource constraints and lack of knowledge as the main reasons farmers do not make changes.

TABLE 6.3: AD ASSESSMENTS OF THE MOST VALUABLE CROPS; 1983

RANK	CROP	MOST FREQUENTLY CITED REASONS
1	SORGHUM	Harvested in Large Quantities
		High Demand
		Multiple Uses
		Stable Yield
2	COWPEAS	High Demand
		High Prices
		Matures Early
		Can Harvest Leaves in Bad Years
3	MAIZE	Good Prices
		High Demand Relative to Supply
		Can Sell Green or Dry
4	MELONS	Easy Management
		Ripens Early
		Multiple Uses
5	JUGO BEANS	Low Labor Relative to Price
		High Demand
6	SUNFLOWER	High Price
		High Demand

Source: 1983 AD Survey.

TABLE 6.4: CHANGES FARMERS COULD MAKE TO INCREASE PRODUCTIVITY, 1983

RANK/a CHANGE	WHY CHANGE WOULD INCREASE PRODUCTIVITY/b	WHY FARMERS DO NOT USE/b
1 - Row Plant	Proper Plant Spacing Helps Weeding Better Seed Depth Less Seed Used	Lack Implements Too Much Work
2 - Fertilizer	Increase Soil Fertility Improve Soil Structure Conserve Soil Moisture	Lack Funds Lack Knowledge Fear More Weeds
3 - Fencing	Reduce Livestock Damage	Lack Funds No Cooperation
4 - Winter or Spring Plow	Improve Soil Moisture	Lack Draft Not at Lands Lack Labor
5 - Early Plant	Leaves Long Time to Mature Use First Rains Reduces Pest Attacks	Erratic Rains Lack Draft
6 - Certified Seed	Quick Maturing Better Germination	Lack Funds
7 - Better Weed Control	Reduce Weed Competition Moisture Conservation	Lack Labor No Benefit
8 - Crop Rotation	Increase Soil Fertility Reduce Diseases and Pests Promotes Different Crops	Lack Knowledge Lack Seeds
9 - Dams	Water for Draft Animals	Lack Funds
10 - Destump	Less Damage to Plows Use Planters & Cultivators	Lack Funds Lack Labor

Source: 1983 Agricultural Demonstrator Survey.

a. Ranking based on the number of times a change was cited. Each AD was allowed to cite three promising changes.

b. Most frequently received reasons are cited. Among cited reasons, no strict ranking is implied. Two "attitude" reasons were cited frequently--farmers lazy and no interest--but have not been included since they do not relate to particular changes.

B. TRADING NETWORK

In Botswana, local trade historically has been dominated by informal exchanges between households. Informal trades are made for labor, traction, gathered items and household products on both a cash and barter basis. In many cases, exchanges are made without specified terms [Duggan, 1979]. Although, as Duggan points out, there is an internalized sense of relative value and it is expected that trades will balance out over time.

During the drought of the 1980s, the importance of informal trade decreased. Households had few products to exchange and, as noted in Chapter IV, cooperative plowing gave way to formal hire draft arrangements. Formal traders certainly were the main source of food and production inputs between 1982 and 1985, if not before.

A key marketing issue affecting crop production is the impact of the trading network on production incentives. One particular issue is the prices farmers receive for their products relative to the prices of commodities available through the traders. Inexpensive food grain imports can discourage attempts to increase production. A second issue is the availability of food. The incentive to invest in crop production is greater if commodities are not regularly available. A third issue is the availability of inputs. It does little good to recommend use of new implements or chemicals if they are not available.

In order to assess the impact of the trading network on crop production incentives in the Central Region, a regional survey was carried out in 1985. There were three main research objectives: (a) to see if there were differences in trading activities by village size, (b) to determine the availability and prices of agricultural commodities and production inputs, (c) to identify constraints on the performance of the trading network, with a focus on supply sources and business problems.

1. PROFILE OF TRADING ESTABLISHMENTS

There was an average of 2.7 traders per village, as seen in Table 6.5. (All results exclude the major villages unless otherwise stated.) The number of traders per village was about the same in the different parts of the region. As would be expected, there were more traders in the large villages than in the small villages. However, the average number of households per trader was actually the lowest in the small villages.

TABLE 6.5: NUMBER OF TRADERS IN THE CENTRAL REGION BY LOCATION AND SIZE OF VILLAGE, 1985

	NO. OF VILLAGES	NO. OF TRADERS	TRADERS/ VILLAGE	HHS/ VILLAGE	HHS/ TRADER
LOCATION:					
Mahalapye West	7	19	2.7	244	90
Mahalapye East	14	43	3.1	202	65
Palapye South/a	11	28	2.5	240	96
Palapye North/a	8	21	2.6	228	88
Serowe	6	14	2.3	207	90
POPULATION:					
Small Villages	21	41	2.0	94	48
Medium Villages	15	41	2.7	239	89
Large Villages	10	43	4.3	468	109
SUB-TOTAL	46	125	2.7	223	83
MAJOR VILLAGES	3	48	---	3786	--
ALL	49	173	---	441	--

Source: 1985 Trader Baseline Survey.

a. Palapye South includes villages south of the Tswapong Hills while Palapye North includes villages north of the Tswapong Hills and on the road to Bobonong.

Ninety percent of the trading establishments were general traders. There were only 15 cooperatives in the 46 villages. Most of the cooperatives were in Serowe and Mahalapye West Districts. In the small villages, there were only three cooperatives.

Most trading establishments were owner managed (63%). The establishments had been in operation for an average of eight years. Around ten percent of the establishments had been in business for more than twenty years. The establishments employed an average of 2.6 full-time employees but few part-time employees. Traders in the small villages only employed an average of two employees, compared to about three in the large villages. Cooperatives employed two to three times as many employees as did general traders. Traders in the major villages had an average of 6.2 employees.

As would be expected, most customers were from the village where the establishment was located. The proportion of traders who considered lands dwellers to be a large share of their customers was greater in the small villages than in large villages (56% of establishments versus 23% in the large villages).

A summary of trading activities in presented in Table 6.6. Essentially all establishments sold agricultural commodities (including canned and processed foods). Many establishments sold some types of implements, but less than a quarter sold fencing materials, livestock requisites or even seed. There were few establishments which had bought either crops or livestock from farmers. The findings on trader activities can be contrasted to those from a trader survey carried out in the Southern Region in 1970 (a year with good rainfall) [DPS, 1971]. While few traders in that study said they sold fertilizer, pesticides or

TABLE 6.6: TRADING ACTIVITIES, CENTRAL REGION, 1985

	AGRICULTURAL COMMODITIES		INPUT SALES					LIVESTOCK	
	SELL	PURCHASE	SEED	CHEM-ICALS	IMPLE-MENTS	FENCE MATER.	LIVES. REQUI.	PUR-CHASE	SELL
			(Percent of Establishments)						
LOCATION:									
Mahalapye West	90	11	26	0	53	26	32	16	0
Mahalapye East	98	5	23	0	42	23	23	7	5
Palapye South	96	11	11	0	21	21	21	0	4
Palapye North	91	0	19	0	38	28	29	5	0
Serowe	100	0	29	7	43	0	29	7	0
POPULATION:									
Small Villages	98	7	22	0	27	12	17	5	0
Medium Villages	95	5	27	7	44	20	29	7	5
Large Villages	93	5	27	7	44	20	29	7	5
SUB-TOTAL	95	6	21	1	38	22	26	6	2
MAJOR VILLAGES	90	4	19	10	31	19	23	0	0
ALL	94	5	20	3	36	21	25	5	2

Source: 1985 Trader Baseline Survey; 173 establishments.

livestock requisites, most did purchase sorghum, maize and cowpeas from local farmers. This suggests that the lack of purchases from farmers in the Central Region may have been due to the drought.

Most traders (79%) made sales on credit but who got credit was generally limited to those that were well-known or who had permanent wage employment. No trading establishment gave credit to all its customers.

2. AVAILABILITY AND PRICES OF FOOD COMMODITIES, IMPLEMENTS AND FENCING MATERIALS

Because of the effects of food access on production incentives, additional data were collected on the availability and prices of the major food commodities in relation to the size of village. Findings on the percent of traders selling the different food grain items, the percent with the items in-stock on the day of the survey, and average prices are summarized in Table 6.7.

The percent of traders selling most items was somewhat less in the small villages compared to the medium and large villages. The differences by village size were greater when comparing how many traders actually had items in stock. Nevertheless, even in the small villages, most items not only were sold, but were in stock. The items which were most consistently in stock were those obtained from wholesalers. Cowpeas, sorghum grain, sorghum meal and bread (obtained from millers or local growers and bakers) were available on a more ad hoc basis.

Turning to prices, imported maize meal was the least expensive, followed by sorghum meal, wheat flour and rice. Cowpeas and other beans were two to three times as expensive. There was a relatively narrow range of prices for any given agricultural commodity. The coefficients

TABLE 6.7: AVAILABILITY AND PRICES OF MAJOR FOOD GRAINS, 1985

	BY SIZE OF VILLAGE SMALL	MEDIUM	LARGE	MAJOR VILLAGES	ALL
PERCENT SELLING:					
Maize Meal	97	89	93	96	93
Maize Grain	79	98	85	96	90
Sorghum Meal	44	71	68	73	65
Sorghum Grain	44	58	35	46	46
Cowpeas	12	31	38	48	33
Bread Flour	85	87	85	93	88
Bread	44	38	50	75	52
Rice	82	84	95	89	88
PCT. WITH IN-STOCK:					
Maize Meal	74	87	90	91	86
Maize Grain	56	84	68	82	74
Sorghum Meal	32	51	43	66	49
Sorghum Grain	24	40	15	30	28
Cowpeas	6	18	15	39	20
Bread Flour	65	71	80	93	78
Bread	21	24	33	75	39
Rice	56	73	88	73	73
AVERAGE PRICE (PULA):					
Maize Meal (kg)	.56	.51	.53	.49	.52
Maize Grain (kg)	.65	.59	.61	.57	.60
Sorghum Meal (kg)	.71	.67	.70	.65	.68
Sorghum Grain (kg)	.43	.38	.38	.38	.39
Cowpeas (kg)	1.25	1.49	1.55	1.58	1.53
Bread Flour (kg)	.87	.79	.82	.75	.80
Bread (loaf)	.77	.76	.80	.74	.76
Rice (500 gms)	.86	.81	.86	.78	.83

Source: 1985 Trader Baseline Survey.

of variations of most prices were under 15 percent. The narrow range of prices can be attributed to the trading margins set by the Price Control Unit of the Ministry of Commerce & Industry. Since the Control of Goods Act was passed in 1973, maximum trading margins have been set for all goods sold by all traders - both wholesalers and retailers.

Prices tended to be higher in the small villages, and lowest in the major villages. The largest and most significant differences were for the items obtained through wholesalers in the major villages.

The availability and prices of implements and fencing materials were also examined, since these are the main purchased inputs in the region. Results are presented in Table 6.8. Only a small share of the traders who reported they sold implements, sold anything but hand tools and plow shares. Less than ten percent of the traders sold plows, planters, or carts. Even a smaller proportion sold harrows or cultivators. There were large ranges of prices observed, mostly due to differences in the features of the items being sold.

3. SOURCES OF ITEMS SOLD

Essentially all traders in the Central Region relied on wholesale depots in Mahalapye, Palapye or Serowe for the items sold. In addition, nearly half obtained some supplies from businesses in towns in Botswana, a quarter from businesses in other countries, and a quarter from parastatals (primarily BAMB). Neither farmers nor businesses in the same village were sources of supply for more than three percent of the traders.

Traders in the major villages relied primarily on wholesalers in the same village. In addition, a significantly greater proportion of traders in the major villages (.95 confidence level) obtained supplies

TABLE 6.8: SALES OF IMPLEMENTS, HAND TOOLS AND FENCING MATERIALS, 1985

	PCT. SELL	PCT. WITH IN-STOCK	PRICES/a LOW	HIGH	MEAN	S.D.
IMPLEMENTS:						
IS Single Plow	10	7	67	270	141	50
IV Single Plow	12	9	40	195	109	32
Double Plow	4	4	334	482	380	46
Row Planter	4	4	203	303	256	32
Plow Shares (8-12")	21	14	3	13	6	3
Donkey Cart	4	1	315	610	456	108
HAND TOOLS:						
Wheel Barrow	14	9	35	72	48	11
Spade	23	15	7	15	10	2
Hand Hoe	23	17	1	6	4	1
Pick	18	15	6	16	11	2
Axes - Small	27	21	4	17	10	3
Axes - Large	b	b	18	29	21	3
FENCING MATERIALS:						
Galvanized Wire	15	13	47	96	65	11
Anchor Wire	8	7	35	90	48	16
Binding Wire	16	12	43	75	63	11
Barbed Wire	10	10	49	80	64	9
Gates	9	6	22	80	51	21
Posts	9	8	4	15	11	2

a. Rounded to nearest Pula.
b. The question did not distinguish by axe size.

in Botswana towns and from other countries than did traders from the other villages.

A majority of traders paid for all their supplies with cash (56%). The remaining traders were able to obtain some of their supplies on credit. A significantly greater proportion of traders in the major villages were able to obtain supplies on credit compared to traders in the other 46 villages (67% compared to 44%; significant at .95 confidence level).

4. BUSINESS PROBLEMS

Business problems were investigated by asking traders which out of a set of ten potential problems were problems faced by that establishment. Findings are presented in Table 6.9. The most frequent business problems were lack of supplies, too much competition, unaccounted losses, and lack of cash for supplies. Unaccounted losses and competition were more frequently cited by traders in the major villages while lack of cash and supplies were cited more frequently by rural traders. When the traders were asked to rank their most important problem, too much competition was ranked overall as the greatest problem.

For comparison, traders in the Southern Region reported in 1970 that their main problems were: (a) lack of transport and the high cost of transport, (b) delays in securing supplies caused by import and export permits, and (c) unpredictable levels of local crop production [DPS, 1971].

TABLE 6.9: BUSINESS PROBLEMS BY SIZE OF VILLAGE, 1985

	SMALL	MEDIUM	LARGE	MAJOR	ALL
	(Percent of Establishments)				
SHORTAGES OF:					
Supplies	66	66	67	58	64
Cash	68	46	51	40	51
Buildings	34	49	30	35	37
Skilled Labor	42	24	30	27	31
Water	42	34	30	21	31
MANAGEMENT:					
Too Much Competition	46	54	58	65	56
Unaccounted Losses	49	44	60	60	54
Poor Transport	44	32	28	29	33
Prices Too Low	37	20	21	27	25
Poor Record Keeping	27	20	23	15	21

Source: 1985 Trader Baseline Survey.

C. VILLAGE GROUPS

Most ministries, including the Ministry of Agriculture, encourage their field agents to form and work with village groups [Willett, 1981]. Village "self-help" activities, including drift fencing and dam construction, nearly always are channeled through groups. The 1983 AD Survey showed that group formation was the second most common topic raised by ADs at village meetings. Consequently, improved guidelines on group formation and management should increase the capacity of the Ministry to promote modified production practices and programs.

This section summarizes recent national research findings on village groups and presents selected findings from Shoshong and Makwate on: (a) the activities and problems of groups, and (b) patterns of participation in groups. The last part of the section reviews experiences with a group formation "institutional experiment" initiated in the 1985-86 season.

1. RECENT RESEARCH FINDINGS

Research on village groups and voluntary organizations has been sponsored by both the Ministry of Local Government and Lands and the Rural Sociology Unit of the Ministry of Agriculture. The objective in most investigations has been to identify group activities and evaluate their contributions to development. Between 1980 and 1985, local institutions were examined by Wynne [1981], Brown [1982], Manzardo [1982] and Zufferey [1983a, 1983b].

Wynne carried out a study of two villages in each of the Gaborone, Central and Southern Regions. She found confusion over the roles of the various village groups. Few villagers felt the voluntary organizations were making an important contribution.

Brown studied local institutions in the Gaborone Region. He found that the Village Development Committees rarely met and were involved in no major activities. Few villages had Farmers Committees. Brown concluded that most village organizations made few contributions to rural development. In what they did accomplish, they were oriented toward infrastructure.

Manzardo's research had a national focus. He reported that organizations which were the product of efforts by ADs usually had small memberships and rarely met. Groups initiated by villagers, on the other hand, generally were committed to some special purpose and were supported by several active farmers.

Zufferey carried out a series of studies of local institutions in the Central Region. He identified a diverse set of problems affecting group organization and operations, including: (a) many members did not understand the purpose of the groups, (b) lack of coordination among groups, and (c) lack of group organization skills.

In summary, local institutions research in Botswana has consistently led to two observations: (a) most group organizations are making few contributions to village development, mainly due to attendance problems and a lack of focus and (b) activities which represent organized responses to locally felt needs consistently are more successful than those formed by extension workers or those which are part of national organization.

2. GROUPS IN SHOSHONG AND MAKWATE

An overview of the major groups in Shoshong and Makwate was initially compiled during the 1984 Village Institutions and Services Survey. Follow-up information on group activities and problems was collected from most of the groups during February and March, 1985.

The studies confirmed that groups in Shoshong and Makwate had the same problems identified elsewhere in Botswana. The groups were an important element of village life but were not operating very effectively. Most of the general purpose groups were oriented toward infrastructure projects. There was a lack of coordination both within and between groups, leading to an overlap in projects and confusion over the roles of different groups. Most groups suffered from poor attendance and a lack of commitment.

The VDCs are supposed to be the focal point of village development efforts, but were not playing this role in either Shoshong or Makwate. The VDCs emphasized projects with few beneficiaries, rather than their role of setting and coordinating a development agenda. The Farmers Committees were completely inactive in both villages.

As found in other studies, the special purpose agricultural groups were among the most active. However, the groups requiring large fees, such as the Shoshong spray race group, tended to serve the interests of a few wealthy villagers. The existence of projects was an important focal point of the more successful groups. Without specific projects, most groups became inactive. Moreover, the groups with better attendance and more committed memberships tended to be those which had personal incentives.

3. HOUSEHOLD AND INDIVIDUAL PARTICIPATION

Household and individual participation in village groups was examined in the 1985 DUMI Study. With reference to permanent groups, more households had participated in 4-B projects than those of any other group. Members from female headed households were more active in village groups, as were those from richer households. In general, more households participated in group activities sponsored by the village extension agents and leaders than they did the activities of permanent groups.

On an individual basis, only seven percent of the enumerated population had participated in village groups. The proportion of individuals participating in groups did not change greatly, regardless of whether a household was in Shoshong or Makwate or was male versus female headed. A slightly greater share of household members in households with more than 15 cattle participated in groups than did those from poorer households.

There were significant differences in individual participation based on gender, role in a household, and age. Ten percent of the females enumerated participated in village groups, compared to only three percent of the males. Most of the participants in groups were either the most senior male or female in a household. Nearly a third of the most senior females and a quarter of the most senior males participated in groups. Group participation was primarily limited to those above age 40.

4. EXPERIENCES WITH FARMER GROUPS

After the above institutional studies had been completed, farmer groups were formed in Shoshong, Makwate and Makoro villages. Formation of the groups represented an institutional experiment. Prior on-farm experiments carried out through individual farmers had failed to stimulate community interest. In addition, the focus of most trials had been on tillage-planting systems and had, as a result, involved a disproportionate number of male headed and richer households. It was hoped that formation of farmer groups would create additional community interest and would broaden the base of farmers involved on-farm research.

As part of the institutional experiment, different types of groups were formed in the three villages. In Makwate, a large, heterogeneous group was formed. In Shoshong, the group was based on active and interested farmers who had adequate resources for farming, but were not particularly wealthy. Most participating households comprised small conjugal units and both spouses were encouraged to attend meetings. In Makoro, the group involved just females and most were from female headed households. In addition, nearly half of the members served on the local VDC. Two of the groups had ten members, while the one in Makwate had 21 members. Most of the individuals attending meetings were females.

Farmer group meetings were held once a month. Meetings generally consisted of three sets of discussion. The first was a review of the farmers' circumstances and problems since the prior meeting. The second was a discussion of trials' implementation (during the early part of the season) and intermediate trial outcomes (during the later part of the season). The final part of each meeting consisted of a discussion of existing government programs and how farmers might take advantage of the program.

Several procedures were followed to increase the likelihood of success: (a) the groups were focused on well-identified problems which were recognized by the farmers themselves as being problems; (b) seed and advice were given to farmers to provide personal incentives for group membership; (c) open discussions of problems and trials implementation created peer pressure to be more active; (d) regular meeting dates were set to reduce the chance that farmers would forget about meetings; (e) meeting agendas were prepared, to make sure meetings appeared to be accomplishing something; (f) each farmer had one or more trials which served as a focal point for farmer involvement in the groups; and (g) farmers were taken on field visits so they could compare their relative progress.

The farmer group experiment was generally successful, although not all problems were resolved. The group discussions were particularly helpful in clarifying the instructions for trials and creating pressure to implement trials. The discussions of general farming problems were less satisfying because most problems had no identifiable solution. For example, there were severe insect pest attacks but there was no possibility of a spraying intervention (neither technically nor economically feasible).

The two smaller and more homogeneous groups in Shoshong and Makoro worked out much better. There was a higher rate of successful trial implementation and there were more vigorous discussions. The most animated discussions took place when farmers interacted on the basis of differing personal experiences. Females attended the group meetings most regularly and were most active in the trials. Males tended to dominate discussions in which they were involved, but often were satisfied to sit back and wait for a topic on which they felt they had relatively greater expertise. The females were more prone to talk about their problems and to seek advice.

After the first season, group members were asked to assess the group meetings. All group members said that they wanted to be a member of the group during the following season. Also, all members said they understood the instructions for the trials which were presented through the group meetings. All but one member said it was useful to hear about the problems of other farmers.

D. PARTICIPATION IN ALDEP AND DROUGHT RELIEF

Despite the amount of Ministry resources funnelled into ALDEP, Drought Relief, and ARAP (beginning the 1985-86 season), there is no systematic monitoring of participation patterns or farmers' assessments of the programs. Resources were not available to carry out the type of monitoring which is needed, but some data were collected on participation in ALDEP in 1983, participation in both ALDEP and Drought Relief in 1985, and farmers' assessments of the programs. The objectives were: (a) to see who is benefiting from the programs, and (b) to identify priorities for a monitoring program (if and when one is established).

1. PARTICIPATION IN ALDEP IN 1983

In the 1983 Agricultural Demonstrator survey, ADs reported that they had processed an average of 13 to 15 ALDEP loans during the year preceding the survey. This can be compared to an average of more than 400 farming families per extension area. The main package requested was fencing, followed by water catchment tanks, implements (primarily row planters) and then the draft power packages.

Meeting asset requirements for the implements package (for which draft power and a destumped field were required), was cited as the main problem farmers' faced in getting approval of loans, despite the focus of ALDEP on resource poor farmers. Supply problems and late approval of loans (relative to the planting season) were also seen as major problems in the ALDEP program. (Since 1983, ALDEP has been changed from a subsidized loan program, to a down payment plus grant program.)

An overview of household participation in ALDEP in Shoshong and Makwate was obtained in 1983 through the Crop Management Survey. Of 116 households in the survey, only 62 percent had even heard of ALDEP. Slightly greater proportions of male headed and poor households had heard of the program, but the differences in proportions were not statistically significant. Only 28 percent of the households which had heard of ALDEP had actually ever applied for the program. The proportions of households which both knew of the program and had applied for subsidized loans did not differ significantly depending on village location, sex of head of household, or cattle assets.

2. PARTICIPATION IN DROUGHT RELIEF AND ALDEP IN 1985

During the 1985 DUMI Study, respondents were asked to indicate which Drought Relief programs they had participated in during the year

preceding the survey, and which ALDEP packages they had ever received.

In the 1984-85 season, nearly all households received seed through Drought Relief. In addition, more than a third participated in the traction hire program and another third in the destumping program. A greater proportion of female headed and cattle rich households participated in the traction hire scheme than did male headed and poorer households, respectively. Participation in the food aid and destumping programs differed significantly by village.

As of 1985, fencing continued to be the most popular ALDEP package. According to the regional ALDEP officer, the fencing package was by far the most popular package throughout the Central Region, followed by the row planter package. Neither water catchment tanks nor the traction packages were in much demand.

3. FARMER ASSESSMENT OF PROGRAMS

During the 1984-85 season, the three main assistance programs in Shoshong and Makwate were the seed distribution, destumping and traction hire schemes, all under the Drought Relief. In the DUMI Study, respondents were asked to assess these programs, plus any ALDEP package they had received.

A majority of respondents felt the seed program most directly benefited females, while males were seen as the main beneficiaries of the destumping scheme. An equal number of respondents said females as opposed to males were the main beneficiaries of the traction hire scheme.

The main source of information for the Drought Relief schemes was village meetings addressed by the ADs. A few respondents said they had heard about the programs through personal contacts with the ADs or from the radio. There was little agreement among the respondents about the qualifications for the various programs, indicating these were not clearly explained to farmers. Many farmers had the impression that qualifications were more stringent than they actually were.

Most respondents approved strongly of Drought Relief (as could be expected). All participants in the destumping scheme said it helped their household, due to additional cash income and the clearing of additional land. However, several respondents said they were not able to take full advantage of the traction hire and seed distribution schemes. For example, more than a third of the participants in the traction hire scheme were not able to arrange for anyone to plow for them. For the same reason, and due to a lack of rain, more than a third of the households did plant the seed they were given.

With reference to ALDEP, an equal number of respondents reported that males versus females were the main beneficiaries, essentially all the respondents heard about the programs at village meetings called by ADs, all felt the programs had helped their household, and all said they would recommend the program to other households. Again, there appeared to be some confusion over requirements, with a tendency to feel requirements were greater than they are.

Most farmers reported that they saw little need to change the programs. The main exceptions were with respect to seed distribution and the traction hire scheme. Nearly half of the farmers receiving seed complained about the Red Swazi sorghum seed distributed in the government program (see Chapter IV as well). Unfortunately, Red Swazi seed was all that the government could obtain but farmers were not made aware of this. Several farmers said that more cowpeas should be distributed through Drought Relief, since a shortage of cowpea seeds was one of their main problems.

With reference to the traction hire scheme, respondents said that there were too few tractors to plow for everyone, even though the government was willing to pay for plowing. Some respondents suggested that the government should regulate the program by setting up plowing schedules. Others suggested that the government should buy tractors and have government drivers supplement private contract services. Some even proposed that the government should subsidize the purchase of tractors. Unfortunately, the suggestions of the farmers conflict with a large body of experience in Africa which shows that government tractor schemes (primarily public hire services and tractor subsidies) have been costly failures [Pingali, Bigot, Binswanger, 1987].

E. CONCLUSIONS AND RECOMMENDATIONS

The objectives of this chapter were to analyze the performance of the agricultural support systems affecting arable farming, and to identify policy and institutional changes to improve their performance. Four support systems were investigated: the extension service, the network of formal traders, village groups, and two agricultural assistance programs. This section presents conclusions and recommendations for the Ministry of Agriculture.

1. EXTENSION

The 1983 extension survey showed that there continue to be major extension problems in the Central Region which go beyond the extension message. The administrative changes introduced during the 1970s have helped but the lack of a coherent extension approach is a major constraint. Five issues should be addressed in order to improve the effectiveness of ADs.

First, most ADs gave the same advice and used the same demonstrations, regardless of extension area circumstances. Extension priorities should be established for each extension area, based on areas characteristics. The key characteristics would appear to be: type of traction used, distance to nearest lands, amount of wire fencing, and percent of farmers using early plowing and row planting. These variables tend to distinguish progressive arable farming areas from those which are less progressive.

Second, most ADs worked primarily with progressive farmers, but did so less effectively than they did under the Pupil Farmer Scheme. An extension approach should be adopted which is in between the Pupil Farmer Scheme and the "community at large" approach. Following the farming systems approach, recommendations should be developed for a few clearly identified RDs. Then, extension workers could work with representatives ("pupils") from each domain. In this way, improvements could be initiated and monitored for a range of farming households, but ADs could be allowed to concentrate on a limited number of households.

Third, the ADs were fully occupied with ALDEP, Drought Relief, and ARAP. Unless the administration of the programs is significantly changed, the Ministry should set-up one or two mobile extension teams in each District to implement demonstrations and hold periodic extension "clinics."

Fourth, the ADs were not adequately prepared for their job. In BAC and in-service training, the emphasis given to technical training should be reduced relative to training in farm management analysis (or farming systems diagnosis). At present, ADs receive essentially no training

which prepares them to deal with human and institutional problems. A recent national extension assessment confirmed that ADs throughout the country do not feel competent in farm management analysis or inquiry methods [Trent, Styles and Ramolemana, 1986].

Fifth, there were essentially no linkages between research and extension personnel. On-farm researchers need to participate regularly in the ALDEP in-service training courses and to periodically attend monthly management meetings. Extension agents assigned to villages where there is on-farm research should be seconded to the on-farm research team. This will improve communication to the other ADs (through reports at the monthly management meetings) and ensure that farmers do not received mixed messages from the research and extension officers.

2. TRADERS

The research on the regional trading network revealed an effective and relatively efficient system for providing food and other consumption items to rural households. The government should be extremely cautious when considering any policy or institutional change which might adversely affect the effectiveness of the local traders.

The main intervention point with reference to the trading network would appear to be input supply. Few traders provided agricultural implements, fencing materials, seed, fertilizer, or livestock requisites. Input availability particularly was a problem in the small villages. The problem of input availability might be addressed as follows.

First, the Ministry's Department of Cooperative Development should encourage member cooperatives to establish schedules for visiting near-by small villages. Farmers could be picked-up, taken to shop, and then returned with their purchased items. This is a practice general traders use to increase their coverage.

Second, since few shops carried the major implements, farmers had little opportunity for comparing prices and features at different traders. To increase competition among suppliers and reduce the information costs to farmers, the Department of Agricultural Field Services should begin monitoring prices of inputs at the large traders and cooperatives, compile a list, and have ADs post it in each of their extension areas.

Third, the Ministry should encourage BAMB to provide seed to traders on credit, overcoming their cashflow problem, and saving BAMB the expense of setting up mobile seed distribution teams. If the model works, it could eventually be extended to agricultural implements.

The severity of the problem of product evacuation was difficult to assess due to the lack of production. A top priority for the Ministry will be to monitor production utilization patterns and trader behavior during good seasons. If product evacuation problems are identified, the Ministry could set-up grain selling days in each village, analogous to the current cattle auction days. BAMB could then develop mobile purchasing units to circulate to the village selling days.

Finally, while the local trading network was functioning reasonably well, there were business problems which affected the service traders provided to farmers. The Ministry of Commerce and Industries should provide training courses in business management at the rural training centers.

3. GROUP FORMATION

The research on village groups was not encouraging. Despite their importance in village life, most groups are not functioning effectively. Since on-farm research and extension activities are supposed to use a group format, improved group formation and management guidelines are needed. Based on the village groups research and the farmer group experiment, group formation should take into account the following issues.

First, groups must have a very specific set of objectives and, preferably, specific projects which serve to focus the group. The failure of many VDCs and Farmers Committees can be attributed to their lack of focus.

Second, most groups need to have a dual membership structure, and an associated dual meeting structure. If a group is small, it will not impact on the village as a whole. But large groups often fall into inaction due divergent interests and lack of organization. Most of the successful groups had small management committees which met regularly and made most of the groups decisions. Other members met only as needed, so meetings were seen as more useful.

Third, some mechanism is needed to ensure attendance. The groups which personally benefited group members had fewer attendance problems. In this context, on-farm trials and demonstrations could be located primarily on the fields of group members, and the ADs could make sure the ALDEP, Drought Relief, and ARAP applications of group members are processed rapidly.

Fourth, even though there should be personal benefits to group membership, the possibility of contributing to the general welfare of the community often was an important motive for the most active group members. One approach would be to have ADs encourage groups to hold field days and to participate, as groups, in the agricultural shows held each year.

Fifth, ADs might need to give special attention to younger farmers. At present, group activities are dominated by senior household members but it is often the younger farmers who tend to innovate. One option might be to set up separate "young farmers" groups. The ADs also should pay more attention to the 4-B clubs, to ensure 4-B activities focus on farming projects.

To develop additional guidelines, the Ministry should turn to the on-farm research teams. By 1985, all the on-farm research teams had started to work with village groups. However, each team used a different approach than the one tried in the Central Region. An effort should be made to review and synthesize the other experiences with farmer groups.

4. ALDEP AND DROUGHT RELIEF

An adequate assessment of ALDEP and Drought Relief could not be carried out, due to limited resources. Because of the money invested in these programs, along with the recently introduced ARAP program, a large scale national assessment of the three assistance programs should be one of the top priorities for the Ministry.

The research carried out on ALDEP and Drought Relief showed that farmers liked the programs and had few suggestions about alternative programs. There did not seem to be any major biases in participation patterns. However, four major problems were identified which, if verified nationally, should be addressed to improve the effectiveness of

the programs.

The most obvious problem was widespread confusion about what was available and what requirements had to be met. The confusion was partially due to the inability of ADs to explain the requirements of the programs. Equally important, the requirements for each of the programs had changed several times. The continual iteration confused both farmers and extension agents. Also, public announcements about the programs often conflicted with the instructions given to ADs by their District Officers.

Second, the programs did not address constraints on input access. For example, many farmers could not plow because of a lack of access to hired traction. A lack of fencing poles often led to delays in installing ALDEP fencing.

Third, many households were unable to meet the minimal down payment requirements for ALDEP. The Ministry might consider setting up village work programs for ALDEP applicants, following the format of the "food-for-work" program of the 1960s, so no cash down payments would be required.

Fourth, there were too many packages for too many farmers. The number of packages not only was a financial drain, it overwhelmed the ADs and District Agricultural Officers. It clearly is necessary to set priorities. This will require macro economic analysis, as well as a national farm level survey.

VII. SUMMARY AND IMPLICATIONS

This chapter: (a) reviews the research objectives and approach, (b) summarizes major findings, (c) identifies implications for the Ministry of Agriculture, (d) gives an assessment of the research approach, and (e) suggests guidelines for future farming systems research.

A. RESEARCH OBJECTIVES AND APPROACH

The goal of the thesis has been to provide a comprehensive, systems analysis of arable farming in the Central Region, and of the factors affecting arable farming, in order to determine arable farming development priorities. To accomplish this goal, the specific research objectives were to: (a) to describe household circumstances and identify implications for technology development; (b) to describe farmers' production practices, priorities and perceptions, in order to determine priorities for technology research; (c) to characterize cropping outcomes and identify production practices which improve cropping outcomes under drought conditions; and (d) to analyze the performance of agricultural support systems in order to identify policy and institutional options to improve their performance.

Guidelines on arable development priorities are needed because the level of crop production is low and unstable in the Central Region, as it is throughout Botswana. To stimulate farm employment and reduce food imports, the Government of Botswana has established several programs which subsidize rural households. The programs are not financially sustainable. Consequently, there is an urgent need to identify ways to develop arable farming which are not based on resource transfers.

The research used the farming systems approach. The farming systems approach: (a) takes a holistic rather than reductionist perspective, (b) generally uses households, farm systems or production subsystems as the unit of analysis, and (c) follows a systems problem evaluation sequence.

The systems approach used in this research took into account three key methodological themes in the farming systems literature: (a) the need to understand how household circumstances affect farm systems performance and options for improvement [McKee, 1984; Moock, 1986]; (b) the value of a "farmer first" perspective [Rhoades and Booth, 1982; Chambers and Ghildyal, 1985]; and (c) the need to analyze agricultural support systems [Norman, 1980].

The research approach, including the data collection procedures, was described in Chapter II. Most of the data were collected in a series of surveys and on-farm trials carried out in Shoshong and Makwate villages between October 1982 and June 1986. Chapter III presented an analysis of household circumstances. Chapter V shifted from a household perspective to a production subsystem focus. Crop systems management was characterized, emphasizing farmers' priorities and perceptions as well as existing practices. Chapter VI continued with a focus on the crop production subsystem, but turned to an assessment of cropping outcomes and modified production practices. Chapter VI returned to a broader systems perspective. Three key support systems were examined, to identify problems and priority institutional changes.

B. SUMMARY OF FINDINGS

Household circumstances were investigated in order to characterize and stratify the relevant farming population. The analysis made it clear that, at least in drought, arable production plays a limited role in meeting household objectives. Labor requirements for competing income activities and for household maintenance resulted in labor shortages for many households. Land resources were inadequate, at least for some households in normal rainfall seasons. Many households lacked the basic complement of draft animals and a plow needed to control the timing of plowing.

It was shown that the pattern of inequality was more pervasive than indicated by previous studies. Households with fewer cattle also tended to have less-developed land resources, fewer implements, cashflow problems, and more limited food consumption. The pattern of inequality was associated with draft-dependent households, not just with cattle-poor and female-headed households. Therefore, from a technology development perspective, the recommendation was made to concentrate on draft access, followed by labor shortages and land shortages. Through this strategy, the Ministry can be confident of addressing the problems of female-headed and cattle-poor households.

The research on crops systems management confirmed that there was little use of recommended practices but also showed that there were important variations in the use of "traditional" practices. There were small differences in practices across the household types, reinforcing the importance of resource control and timely field operations. Based on the review of crop systems management, several priority technical investigations were identified. None of the proposed investigations would require substantial changes in practices or resource requirements.

The chapters on household circumstances and crop systems management both revealed the importance of gender roles in labor use and decision making. The chapters also showed that resources and practices differed significantly across villages. Therefore, the argument was made that the targeting of research and extension activities must in some cases focus on individuals or villages, not just on households.

Several technological options for enhancing the production potential of Batswana farmers were examined. Although outcomes of the research program were dominated by a severe drought, some profitable options were identified.

The intervention with the greatest potential for increasing farm productivity is row planting. Additional farm production and employment could be generated, and the system has the potential to be expanded without a weeding labor constraint. In FI trials during the 1983-84 and 1984-85 seasons, early plowing plus row planting increased yields by more than 40 percent. Farmers could have made an extra Pula per hour by shifting to row planting (or an extra P20 per hectare with labor valued at P0.38 per hour). Yield increases with row planting were even greater in RI trials.

Double plowing was equally profitable and represents an appropriate intermediate technology, since no planter is required. The main disadvantages of double plowing are: (a) a full draft team is needed twice as often and (b) the relative gain is sensitive to the soil environment and post-planting rains. Nevertheless, on soils with high water holding capacity, a shift to double plowing increased net income per hectare by more than one hundred Pula (based on RI trials in

1985-86).

The main options identified for draft-dependent households were: (a) sole plantings of secondary crops and (b) hand planting for gap filling. Small plots of secondary crops (a) would not interfere with household food objectives, (b) would not require much additional labor, and (c) would increase farm profitability. Hand planting for gap filling provided returns exceeding the urban wage rate, despite drought and low yields.

The research on the extension service showed that there are major extension problems in the Central Region. The lack of a coherent extension approach was identified as a major constraint. At present, the extension approach is based on village meetings, groups and demonstrations. However, only 1-2 demonstrations per year are implemented in each area, the same messages are promoted at village meetings regardless of extension area characteristics, and few ADs work actively with village groups. Moreover, extension contacts are biased toward male and progressive farmers. To improve the effectiveness of the extension service, guidelines were presented for a modified extension approach which builds on the FSR concept of recommendation domains.

The trading network was examined because of the importance of food purchases and purchased production inputs. It was shown that essentially all farmers have access to grain and meal at low prices. Few traders, however, sold seed, farm implements, livestock medicine or fencing materials. Alternatives for increasing access to inputs were suggested.

The research on village groups showed that most groups are not functioning effectively. Nevertheless, an "institutional group formation experiment" was conducted successfully, resulting in higher trials implementation rates than had been achieved using an individual contact approach. With proper group formation guidelines, village groups could be used to expand the coverage of on-farm research.

C. IMPLICATIONS FOR THE MINISTRY OF AGRICULTURE

This section identifies five major implications of the research for the Ministry of Agriculture. Taken as a whole, the recommendations outline a strategy through which the Ministry can make a substantial contribution to arable farming development over a ten to twenty year horizon.

1. SHIFT TO A HOLISTIC, SYSTEMS APPROACH

Perhaps the single greatest implication of the research is the need to approach arable farming development in a holistic, systematic manner. This recommendation applies to the way the Ministry functions, as well as to the scope of the development agenda.

The review of technical research showed that no major solutions exist for dryland arable farming. Even if solutions are found, they will be hard to implement due to the number of potentially binding resource constraints. On the other hand, there do appear to be some options for contributing to arable farming development through institutional and policy changes. Even so, it is not likely that substantial improvements will result from any single change. Therefore, a wide range of technological, institutional and policy interventions must be developed.

A holistic approach is both possible and affordable. Although the Ministry as a whole must use a holistic approach, not everyone working in the Ministry must. For example, the RSU could focus on village institutions and farmer decision making. BAMB could be assigned responsibility for working on input supply. A holistic approach would encourage an evaluation of the activities of each department and division in terms of their contribution to a well-defined development strategy, which encompasses institutional improvement as well as technological change.

The biggest constraint preventing the Ministry from addressing arable farming development in a holistic manner is the lack of communication between the various departments. DPS develops plans based on technical assumptions which are not supported by research. DAFS promotes technologies which DAR officers feel are no better than existing practices. BAC does not provide the type of training ADs need, and DAR researchers provide little or no input into the BAC curriculum.

To improve communication, the Ministry should pursue the concept of decentralization, as proposed in the NDP. Regional officers should be appointed for the DAR and DPS, corresponding to the RAOs in DAFS. These officers could work together to design and implement region-specific strategies for the Ministry. It would not be necessary to add new officers to fill the positions. Rather, as officers are trained over time, an increasing share of trained officers should be allocated to regional positions.

2. GIVE GREATER EMPHASIS TO "INTERMEDIATE" PRODUCERS

A major policy issue in Botswana is whether the government should be devoting so much of its scarce resources to the traditional arable farming sector. The last NDP, for example, mandated the Ministry to give more attention to non-traditional producers, and to irrigated farming [MFDP, 1985]. The National Food Strategy pays little attention traditional producers relative to non-traditional producers and food imports [RDC, 1985].

Efforts to develop non-traditional producers certainly could help, and should be pursued as part of a holistic development strategy. But there is a limit to the potential contribution from the non-traditional producers, both with reference to food production and employment opportunities.

The Ministry can make a larger contribution to national development objectives by devoting more resources to improving the productivity and capacity of the "intermediate" traditional farmers. The intermediate farmers are those who consistently cultivate more than ten hectares, often own (or at least hire) tractors, intentionally try produce a surplus for sale, have above-median cattle wealth and well-developed land resources, and row plant (or at least do "progressive traditional" practices such as early planting).

With appropriate access to inputs and extension advice, the intermediate farmers should be able to make a substantial contribution to national food requirements. Research on appropriate techniques for the intermediate farmers could, for the most part, be carried out in conjunction with research on techniques for the Barlong, Tuli Block and Pandamentenga farmers.

Policy and institutional support is needed for the intermediate farmers, as well as appropriate production techniques. For example, it would be desirable to have the landboards allocate substantial blocks of land. Also, steps to create a rural wage labor market for agriculture would be beneficial, since many traditional farmers face labor shortages due to their higher levels of production. Many intermediate (and non-traditional) producers also need to have better access to short term loans.

The recommendation to give greater attention to intermediate farmers does not imply that the Ministry should abandon efforts to help poor farmers. Instead, the recommendation is to adopt a dual strategy toward the traditional arable farming sector. For the majority of poorer farmers, the focus would continued to be on resource transfers (mainly through ALDEP) and modest technical interventions. However, the Ministry of Agriculture cannot expect to solve the problems of the resource poor <u>and</u> make substantial progress in arable farming development. Most of the needs of the poor will have to be addressed by other ministries.

3. TARGET RESEARCH, EXTENSION AND PLANNING ACTIVITIES

There is a need to develop a comprehensive strategy for targeting the Ministry's planning, research, and extension activities. Targeting serves two interrelated functions. First, it clarifies the relevant population for each technology and program. This should help field personnel when providing advice, explaining options, and processing applications. Second, targeting can be used to establish priorities for technology and program development. An example is the attention given by the Central Region research program to post-establishment management practices--because some interventions were needed for draft-dependent households.

The research suggests that different targeting strategies could and should be used for planning, research and extension activities. The primary criterion for planners (focused on assistance programs) should be cattle assets. Cattle assets are an excellent proxy for overall wealth, cashflows and food consumption. Gender of household head could serve nearly as well, but several researchers have rightly noted that there is great diversity within the category of female-headed households (for example, Kervin [1977] and Gulbrandsen [1980]).

Technical researchers should use draft access as a stratifying variable. Within each draft access research domain, a range of options should be developed to address labor constraints and, as a second priority, land constraints. Reducing the work burden of women should receive increased emphasis relative to tillage-planting interventions. To the extent possible, all interventions should require minimal cash investments.

Targeting for the extension service should first focus on extension area characteristics, so "themes of development" can be developed for each area. Within each area, ADs should try to set up groups representing the draft access domains. Special groups should also be set up for young farmers and for women.

4. SHIFT THE FOCUS OF TECHNICAL RESEARCH

In the past, technical research has emphasized the development and evaluation of new tillage-planting systems, crops and varieties, and implements which perform new functions. Most new systems and implements have failed when tried on-farm, and few farmers have adopted the Ministry's extension recommendations. The failure of the Makgonatsotlhe tool-carrier is a classic example of what happens when researchers try to radically transform existing practices through package approaches and "single best" solutions.

In future technical research, there should be less emphasis on the development and introduction of new systems. Two alternative, but complementary, types of investigations should instead be emphasized.

First, technical research should focus on the relative advantages of alternative practices, varieties and implements under different environmental (and household) circumstances. From the Central Region research, the example of double plowing can be cited. Overall, the benefits of double plowing are marginal but they can be substantial when double plowing is done on soils with high water holding capacity. The objective of this type of research would be to quantify expected benefits.

Second, technical investigations should focus on identifying ways to modify traditional practices (to increase farm productivity) and existing extension recommendations (to make them more attractive to farmers). Many farmers feel that the existing recommendations, particularly row planting, could increase their production, but feel they have constraints which prevent adoption. Researchers need to help farmers figure out how to "fit" the new practices into their existing production system.

5. INCREASE THE EMPHASIS ON MACRO POLICY ANALYSIS

Most Ministry economists are involved in generating data for planning purposes or in analyzing various programs and projects. The task of addressing problems in arable farming development has been turned over to the on-farm research teams. However, the contribution of on-farm research to policy and institutional analysis is limited. Micro-economic research can identify problems and determine guidelines for potential solutions, but the range of factors considered in micro-research is too narrow to solve national development problems.

Therefore, a top priority for the Ministry is to reallocate some of its scarce social scientist resources to the macro economic analysis of arable farming development policy. Urgent analyses are needed on tractor importation and/or subsidies, food grain pricing and food imports, and the relative employment and income effects of the ALDEP versus Drought Relief versus ARAP.

One goal should be to make sure government revenues are used efficiently. A longer-term goal should be to develop a realistic sectoral development strategy, so that when new projects are solicited or proposed, the Ministry can make sure the proposals contribute to sector development goals. The NDP prepared by the MFDP is not sufficient for this purpose.

E. ASSESSMENT OF RESEARCH APPROACH AND GUIDELINES FOR FUTURE RESEARCH

The research presented in the thesis had a broad focus, synthesizing findings from several surveys and experiments conducted over several years. The surveys and experiments were primarily based on a small sample of farmers from two representative villages. This section: (a) briefly reviews the reasons why a small sample, representative village, holistic approach was used; (b) points out the major limitations of the approach, and (c) suggests priorities for future farming systems research.

1. REPRESENTATIVE VILLAGES

The representative villages approach was based on the view that differences among farmers within a village often are more important for assessing agricultural programs and technologies than are differences across villages. On balance, the thesis confirms this viewpoint--at least for Botswana. The two regional surveys (the Agricultural Demonstrator and Trader Baseline surveys) both showed that arable farming practices and circumstances were relatively similar throughout the Central Region. The analyses of circumstances for households in Shoshong versus those in Makwate did reveal substantial differences, but this only gives an argument against a single-village approach--not a representative villages approach.

Future farming systems research should concentrate on a small number of villages, rather than covering many villages or using large national or regional surveys. It would be desirable, however, to make two adjustments in the representative village approach. First, it would be better to cover at least two villages for each "type-of-village," to help distinguish unique village features from the "representative" village features. For example, are all donkey villages poor, just because Makwate is a poor village? The first adjustment implies working in 6-8 villages rather than three, as done by the Central Region team. Second, periodic regional verification surveys should be administered. As long as the surveys are focused on specific issues (ie., are not large baseline surveys), it should not be too expensive to carry out a regional verification survey once a season, or every second season.

2. SMALL SAMPLES

The main reasons for using small samples of farmers were: (a) to minimize measurement errors in resource monitoring and enumerator errors in subject surveys, and (b) to reduce the amount of researcher time required for checking, cleaning, and analyzing the resource flow data. From a practical standpoint as well, it was not necessary to generate "large sample" baseline data because regional and national data were already available, even if insufficiently detailed and disaggregated for farming systems diagnosis.

In retrospect, the small sample approach worked extremely well for the subject surveys, but not so well for the resource monitoring. The small samples for the subject surveys enabled existing staff to conduct all the surveys at non-peak periods. Therefore, both the real and opportunity costs of the approach were almost nil. Data entry and analysis for several of the surveys took less than ten person-days.

To refine the small sample-subject survey approach, three steps should be taken. First, conduct only one large (baseline) subject survey each year. The first season was over-loaded when three large surveys were administered. Second, a core of "cooperator" farmers should be included in the large surveys, to eventually generate a complete household profile and to enable an analysis of trends over time. Third, new farmers should be selected for each survey, to supplement the cooperators. This will reduce the burden on cooperating farmers and enable verification of key issues with new samples.

The small sample strategy for resource monitoring was not so successful because, as it turned out, it was an impossible task to eliminate data errors. Too much time would have been required, and the opportunity cost was too high.

A major question is whether farming systems teams should be investing in resource monitoring. In Botswana, the answer is "no." Due to the difficulty and cost of resource monitoring it would be a poor use of resources relative to the information gained. In this study and previous studies, many of the resource flow patterns of households have

been well outlined. To the extent on-going monitoring is required, this should be the responsibility of the DPS, not the farming systems teams. Therefore, as an alternative to their own resource monitoring, the farming systems teams should meet with the Farm Management Unit to revise the National Farm Management Survey, to make that survey more useful.

3. HOLISM

Perhaps the most distinctive feature of the thesis is the number of topics covered. The holistic approach, in part, obtained from the particular circumstances of the research. It was possible to cover many topics because the research did extend over four years. The topics covered during the first year were, in many respects, the most crucial (crop management, draft arrangements, and the extension service). It was possible to cover other areas because the drought reduced the time required for analyzing trial outcomes.

A holistic approach was followed for three methodological reasons as well. First, investment of research resources in any single information gathering or data analysis activity results in rapidly diminishing returns. Many of the subject surveys--and related analyses of household circumstances, crop systems management and agricultural support systems--only identified major issues. But they did so at low cost. A valid question can be raised as to the utility of more in-depth analysis until such time as a strategy is developed about the major issues.

Second, the major function of this thesis was to provide guidelines on arable development priorities, in order to contribute to the formulation of a viable development strategy. Strategic-level analyses inevitably require a broader range of information than is required for making decisions about particular issues or problems.

Third, to have focused on one or two problems in Botswana would have been an obvious violation of two of the distinguishing principles of the systems approach: (a) optimization with respect to a part of a system does not necessarily mean that the performance of the entire system will be improved, and (b) because of the synergistic interactions of systems components, systems cannot be studied by considering their components in isolation. While it is possible to study particular components using a systems perspective, this was not feasible in Botswana because: (a) the harsh environment precludes substantial improvement from any single systems change, and (b) arable farming is some respects a minor contributor to household objectives, and a minor contributor (at present) to national objectives.

Although there are many advantages to a holistic approach, there are some costs. Three of the most important are: (a) there is less depth in the analysis of any given issue, (b) it generally is necessary to make forays into areas where other researchers have greater expertise, and (c) the range of issues addressed can be overwhelming--leading to inaction due to uncertainty about priorities. The first "cost" is not so severe in a multi-year program. In this research, tillage-planting interventions and farmers' practices and priorities were investigated in-depth because of their high priority while other topics were addressed with a minimal research investment.

The "expertise" issue is a real problem, since systems research is inevitably multi-disciplinary in scope. It clearly is necessary to have back-stopping from several disciplines if resources are not available for a large research team. The research approach was feasible in the Central Region because the team members had formal disciplinary training in economics, anthropology, political science, production agronomy, and plant breeding. This situation will not always obtain on a small team. If it does not, it certainly would be better to focus investigations on areas which can be competently addressed, rather than to adopt a holistic approach as a methodological principle.

Finally, the issue of policy-maker "overload" should not be the determining criterion of whether a holistic approach is used or not. There is always a bureaucratic bias in favor of a focus on one or two problems, one or two priorities, and one or two solutions. The determining criterion should be a comprehensive "needs analysis" related to systems performance. In the case of arable farming in the Central Region, there was a greater need to identify priorities in several areas than to solve a specific problem. Once Ministry officials have a viable development strategy, future farming systems research can be more focused on specific problems and issues.

APPENDIX

APPENDIX

PROFILE OF AGRICULTURE IN BOTSWANA

The appendix presents an overview of agriculture in Botswana. The objectives are to characterize the research setting and place the research into a national agricultural development context. The first section describes the technical environment, including rainfall patterns, temperature, soils, and vegetation. The second section presents an overview of the agricultural sector. The final section reviews the important national and local institutions affecting agriculture.

A. TECHNICAL ENVIRONMENT

1. RAINFALL

Rainfall is the single most important factor affecting agriculture in Botswana. In eastern Botswana, where most arable farming takes place, annual rainfall declines in a diagonal transect from 600 mm. in the northeast to 250 mm. in the southwest. Most of the annual rainfall is received during the summer rainy period, generally beginning in late October or November and continuing to March. However, the beginning of the rains is often late, there is a high frequency of prolonged dry spells during the growing season, and rainfall tends to be localized.

Most rainfall analyses have focused on inter- and intra- annual patterns. No significant correlations have been found between years or between periods within seasons [Pike, 1971; Bhalotra, 1984; 1985]. Dyer and Tyson [1977] did identify a twenty year cycle, ten years of wet and ten dry, for the South African sub-continent but it has too much annual variability to be of use in prediction for any given year. The 1970s were accurately predicted to be above average rainfall years while the 1980s were predicted to have below average rainfall.

With reference to the Mahalapye area, Siebert [ATIP, 1986] calculated an average annual rainfall of 464 mm. over a 73 year period, with more than 80 percent of the total expected from November through March. Rainfall was substantially below the long term average during the years when the research was conducted. With the exception of a freak month (March, 1983, when 257 mm. fell), rainfall averaged only 270 mm. per year during the first three season, with poor distribution.

2. TEMPERATURE AND EVAPORATION

There are two crop production problems caused by temperatures. First, during December and January, the period with the highest probability for rain, it is hot. Daily maximum air temperatures average 33 degrees celsius, and can reach 40 degrees or more. This can lead to soil surface temperatures of as much as 60 degrees but the cardinal temperature for sorghum seedling viability is 40 to 47 degrees. Thus, temperatures alone can have a detrimental effect on seedling establishment.

The second problem is the onset of cool nights at the end of the season. The cardinal temperature for sorghum maturation is around 15 degrees celsius. This temperature is commonly reached at night beginning in April. As a result, February plantings often will not reach harvest stage before the maturation process is slowed. If there are even short drought periods, during which sorghum stops growing, even January plantings may not mature.

High temperatures, along with radiation and wind, lead to another problem--high evaporation and evapotranspiration rates. Evaporation rates have been estimated to be around 1.7 to 1.9 meters per year. Evapotranspiration rates are around 1.4 meters per year, with daily rates exceeding 5 mm. In every month of the growing season, these rates exceed expected rainfall.

3. SOILS

Siderius [1972] reported that the arable part of Botswana is covered by ferruginous tropical soils. Many soils are shallow and have low water holding capacity. Most soils are weakly developed, consisting of medium to coarse grained sands and sandy loams. In many places, the soils are subject to crusting following heavy rains. Most soils are deficient in phosphorus, have low (but variable) levels of mineral nitrogen, and are very low in organic matter.

Siebert [ATIP, 1986] made a detailed assessment of soils in the Mahalapye area based on an analysis of soil samples from 41 fields in the villages where the Mahalapye team has conducted research. Most soils are high in coarse grained sands (sand being more than 50 percent of the soil mass) with a sandy loam to sandy texture. These soils are more easily plowed than are the sandy clay loam soils in the area but their pH values are low for sorghum production, phosphorus is very low, organic matter is almost not present and the total base saturation is low. There is tremendous within-field variability, some of which is significantly associated with micro-topography.

4. VEGETATION

Tree savanna zones cover most of the arable parts of the country. These zones are dominated by Acacia. Several species of Acacia are

bushes which encroach in areas with sandy loam soils, particularly where there has been overgrazing or heavy cultivation.

Siebert [ATIP, 1986] noted that arable activity in the southern part of the Central Agricultural Region is mainly carried out in woodlands (or tree savanna) dominated by _Combretum apiculatum_ and _Acacia nigrescens_. These woodlands give away in the northern part of the Region to _Colophospermum mopane_ bushveld. The transition in vegetation from south to north is accompanied by an increase in soil clay content and alkalinity. There is variability of vegetation types within localities due to soil texture, soil reaction, topography and land use.

B. AGRICULTURAL SECTOR OVERVIEW

1. SECTOR STRUCTURE

Two subdivisions usually are made when characterizing the agricultural sector in Botswana: livestock and arable farming, or traditional and freehold. The sub-division of the sector into traditional versus freehold is based on a special tenure arrangement made for the white minority. The small freehold sector, which in 1983 comprised 360 farms, accounts for a disproportionate share of area cultivated, total food crop production and cattle offtake. Selected characteristics of the freehold and traditional sectors, as of 1983, are presented in Table A.1.

The Sixth National Development Plan [MFDP, 1985] identifies (for the first time) two sub-groups within the traditional sector. One group comprises "intermediate" farmers who own above average cattle herds and aim to produce a surplus to market. These farmers generally cultivate over ten hectares. In 1983, the farmers cultivating over ten hectares

TABLE A.1: FARM STRUCTURE: TRADITIONAL AND FREEHOLD SECTORS, 1983

	TRADITIONAL	FREEHOLD	ALL
TOTAL FARMS	82,000	360	82,360
FARMS WITH LAND	60,900	150	61,050
AREA PER FARM WITH LAND	5.0	166.7	5.4
FARMS PLANTING CROPS	48,100	100	48,200
CEREAL PRODUCTION PER CROP FARM	0.2	53.5	0.3
FARMS WITH CATTLE	58,300	345	58,645
CATTLE PER CATTLE FARM	41.3	1,190.4	48.1
CATTLE OFFTAKE PER CATTLE FARM	4.0	496.2	6.8
SMALLSTOCK	901,800	45,700	947,500
SMALLSTOCK PER FARM	11.0	126.9	11.5
CHICKENS	660,800	300,000	960,800
CHICKENS PER FARM	8.1	833.3	11.7

Source: Ministry of Agriculture, Division of Planning & Statistics, 1984.

accounted for 73 percent of total cereal production even though they represented just 6.3 percent of the traditional farms. The second group have few or no cattle and often are not able to grow enough sorghum to cover subsistence requirements.

Dryland arable farming, whether traditional or freehold tenure, now is also being distinguished from two systems not so reliant on rainfall. One is irrigated farming. There are only about 1,000 hectares under irrigation in Botswana, nearly all of it on the freehold farms. The second is the traditional system (in the northwest) of "melapo" farming. Melapo are flood recession fields in which crop establishment and development takes place mostly on residual soil moisture.

2. CROPPING PRACTICES

Cropping practices are quite similar throughout Botswana. Table A.2 shows that sorghum is the most important crop in four of five of the major agricultural regions, with Maun being the exception. The Maun

TABLE A.2: CROPPING PRACTICES BY AGRICULTURAL REGION: TRADITIONAL SECTOR, 1983

	SOUTHERN	GABORONE	CENTRAL	FRANCISTOWN	MAUN	WESTERN	ALL
CROP FARMS/a	7,900	13,700	14,800	6,200	5,100	400	48,100
FARMS GROWING (% OF FARMS):							
Sorghum	82	99	99	94	55	50	90
Maize	66	70	59	85	63	99	68
Millet	1	12	9	76	41	0/b	21
Beans	34	69	61	66	20	75	56
DRAFT POWER (% OF FARMS/c):							
Cattle	73	72	45	69	77	63	64
Tractors/d	20	26	33	15	4	13	24
Donkeys	6	2	20	5	12	25	10
DRAFT ACCESS (% OF FARMS):							
Own	68	49	53	63	57	38	56
Hire-in	14	26	29	11	24	25	23
Other/e	18	25	18	26	19	37	21
PLANTING METHOD (% OF FARMS):							
Broadcast	75	93	97	98	85	100	91
Other/f	25	7	3	2	15	0	8

continued next page

Table A.2 (continued)

	SOUTHERN	GABORONE	CENTRAL	FRANCISTOWN	MAUN	WESTERN	ALL
SEED PLANTED IN CROP MIXTURES (% OF SEED PLANTED):							
Sorghum	43	71	76	98	83	99	70
Maize	48	76	75	98	50	88	69
Millet	99	95	94	99	36	--	87
Beans	76	97	75	98	99	99	87
FERTILIZER USAGE (% OF FARMS APPLYING):							
Chemical A	12	2	0	0	2	0	3
Manure	14	2	1	16	1	13	5
WEEDINGS (% OF FARMS)							
None	49	23	26	10	2	63	23
Once	51	72	72	87	62	38	69
Multiple	9	5	1	3	36	0	8

Source: Ministry of Agriculture, Division of Planning & Statistics [CSO, 1984].
a. Farms which planted crops in 1983.
b. Zero is entered for less than .5 percent.
c. Does not sum to 100; remaining farms use cattle and donkeys.
d. Includes farms using animals as a supplement to tractor draft.
e. Includes borrowing and obtaining through cooperative agreements.
f. Primarly row planting; some farms use harrows to plant.

Region, in the northwest of the country, has greater rainfall and is ecologically similar to southern Zimbabwe and Zambia. Maize and millet are of above average importance in the Francistown Region. Cowpeas are an important intercrop throughout the country.

Nearly all land is mechanically plowed using mouldboard plows. Most draft power is provided by cattle, usually teams of six to eight oxen. Tractor and donkey traction are rapidly becoming major sources of draft power, particularly in the Central Region. Private contract services account for most of the tractor traction used. A majority of farms relied on traction they owned in 1983.

Nearly all crops are broadcasted and most seed is planted in mixtures. Row planting has made the greatest inroads in the Southern Agricultural Region. Very few farmers use fertilizers, either manure or chemical. Few weed more than once and many do not do a single weeding unless a sufficiently promising plant stand is achieved.

3. LIVESTOCK MANAGEMENT AND HUSBANDRY

Livestock management practices differ greatly between the freehold and traditional sectors but are similar throughout the communal areas. In communal areas, cattle are allowed to graze freely near the cattle posts or lands of their owners [Carl Bro International; 1982]. However, it is a standard practice to have at least one corral and associated calf pen. Lactating cows are often penned part of the time for milking. Calves generally are penned for the first several months of their lives. General herding is done only occasionally, most commonly when there are crops being grown or there is a long distance to water. The standard practice for avoiding crop damage is to maintain a separate residence where cattle can be kept (a "cattle post") which can be quite a distant from both the village and the lands areas.

Since there are few permanent water sources in Botswana, livestock are usually watered at boreholes or open wells during the dry season. When there are rains, dams and pans become the main source of water.

The most common husbandry practices are vaccination, deticking, castration, and dehorning. Cattle generally are vaccinated against anthrax, quarter evil and brucellosis. External parasites usually are controlled on an ad hoc basis through the hand application of "tick grease." Castration is generally carried out at three to four months using a burdizzo (a pinching implement). Approximately half the cattle are dehorned.

Few farmers regulate the breeding of their animals. Nevertheless, there is a distinct calving season, with most calves being born during the rainy season. Most bulls are selected from within the herd. Periodically, owners obtain new bull through purchases or exchanges with neighbors. In few cases do herd owners seek out improved breeds to upgrade their herds.

C. AGRICULTURAL INSTITUTIONS

Primary responsibility for development of the agricultural sector rests with the Ministry of Agriculture. A number of parastatals have been created to supplement private channels for credit, input supply, marketing and trade. At the local level, several organizations coordinate and initiate development activities.

1. MINISTRY OF AGRICULTURE

The Ministry of Agriculture has three major departments: Agricultural Research, Agricultural Field Services, and Animal Veterinary Services. The major units responsible for research and extension activities are the Departments of Agricultural Research (DAR) and Agricultural Field Services (DAFS), respectively. DAFS is the largest department, followed by Veterinary Services.

The function of the Department of Agricultural Research (DAR) is to provide information and technologies so agricultural production can be increased and made more reliable. The DAR consists of a Division of Arable Research, an Animal Production Research Unit, an Estate Management Unit, and a Laboratory Services Unit. The Division of Arable Research is responsible for a Seed Multiplication Unit.

Livestock research is conducted under auspices of the Animal Production Research Unit (APRU). APRU conducts research on 16 MOA ranches spread throughout the country. APRU's first priority has been development of a technical basis for a commercial beef industry. Range management, range improvement, beef cattle nutrition, and beef cattle reproductive physiology have been the major areas of investigation.

The Department of Agricultural Field Services contains four major Divisions: Animal Production, Crop Production, Land Utilization, and Agricultural Management Associations. An Agricultural Information Section, servicing the entire MOA, and a Field Section are also included. The latter is responsible for all direct farmer contact by the MOA, except that done by the Department of Veterinary Services.

There are four levels of staff in Agricultural Field Services: (a) administrators and subject matter specialists at headquarters, (b) agricultural officers and specialist officers in the six regions (specialists are responsible administratively to the regional agricultural officers, but are responsible technically to their division chiefs), (c) agricultural officers and supervisors in the 22 agricultural districts, and (d) agricultural demonstrators in the 225 agricultural extension areas. Extension work is funnelled through the agricultural demonstrators (ADs).

The Department of Veterinary Services is responsible for disease prevention and control, meat inspection, tsetse fly control, administration of livestock advisory services (mainly input distribution), trek route supervision, operation of a diagnostic laboratory, and veterinary research.

The Ministry also includes a small Department of Cooperative Development, the Division of Planning and Statistics and the Botswana Agricultural College. The Division of Planning and Statistics (DPS) is responsible for agricultural sector planning, an annual national agricultural survey, an on-going farm management survey, and rural sociology research. The DPS is administratively attached to the office of the Deputy Permanent Secretary. Botswana Agricultural College provides training in technical agriculture through the diploma level. BAC has trained most of the agricultural demonstrators in Botswana.

2 . INPUT SUPPLY, CREDIT AND MARKETING AGENCIES

Several governmental and parastatal agencies have been created to promote development of the agricultural sector. Most have focused on commercial production, with a particular emphasis on nurturing the important export beef market.

The most important agency is the Botswana Meat Commission (BMC). BMC has a statutory monopoly over exports of meat and meat products, and accounts for four-fifths of all cattle slaughtered in Botswana. BMC has two abattoirs, one of which is the largest single manufacturing enterprise in the country. BMC provides government revenue through a turnover tax. Prices are set for different classes and change over the year to encourage sales outside of the peak April to June sales period.

Two additional agencies directly serve the livestock sector. The Botswana Livestock Development Corporation (BLDC) buys cattle which are not yet ready for slaughter and has attempted to develop finishing ranches. BLDC is specifically targeted to serve remote area purchases. The Botswana Vaccine Institute (BVI) was set-up to produce an effective foot and mouth disease vaccine. BVI is capable of an annual production of more than 20 million doses [MFDP, 1985].

The most important agency affecting crop production is the Botswana Agricultural Marketing Board (BAMB). BAMB has three basic functions: (a) to provide guaranteed, equitable prices, (b) to purchase enough domestic produce to meet emergency demand requirements, and (c) to provide necessary seed and chemical inputs to farmers. BAMB has marketing facilities at 26 locations and a storage capacity of 55,100 tons. BAMB played a major role during the drought in purchasing seed internationally.

The National Development Bank (NDB) and the Botswana Development Corporation (BDC) provide credit and support services to both traditional and large scale commercial operations. The NDB is the major source of credit for farmers, currently providing more than half of all lending to the agricultural sector [MFDP, 1985]. The BDC promotes and assists commercial operations and, in agriculture, has concentrated on irrigation and dairy farming. BDC freehold farms account for the largest irrigated area in Botswana.

3. VILLAGE GOVERNMENT AND ORGANIZATIONS

Since independence, traditional village authority, vested in a headman and village meetings (kgotlas), has been subsumed into local governmental structure. Village leaders are responsible to District Councils. District Councils are under jurisdiction of the Ministry of Local Government and Lands (MLGL). Land Boards under authority of the District Councils have been given authority to allocate tribal lands.

Village Development Committees, created under the authority of District Councils, are the executive authority in charge of development at the village level. A village may also have a village extension team (VET) comprised of the AD, the assistant community development officer (village representative of the MLGL), a family welfare educator (FWE) and the head teachers of the local schools. Most villages have one or more Farmers' Committees which work together with the ADs to implement Ministry projects.

Local branches of various types of cooperatives can be found in many of the larger villages. Consumer cooperatives create retail outlets for consumer goods while various marketing and multi-purpose cooperatives provide farm inputs, sell consumer goods, and purchase livestock and farm produce. Local cooperatives are supported through two secondary societies, the Botswana Cooperative Bank and the Botswana Cooperative Union, and by the Ministry of Agriculture's Department of Cooperative Development.

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