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LESOTHO FARMING SYSTEMS RESEARCH PROJECT

Program Report
1979–1986

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Research Division, Ministry of Agriculture and Marketing

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PREFACE

Many donor projects in developing countries have not adequately documented their work so it is accessible and useful to the government of the country, succeeding projects, or interested others. The Farming Systems Research Project, implemented by Washington State University in partnership with the Ministry of Agriculture's Research Division, has documented its activities extensively. This report summarizes more than 4,000 pages published in over 180 documents during the 7-year life of the project. A supplement will cover 1985-86 experiments and activities.

For more detail on any topic covered in this report, the reader is referred to the Research Division/FSRP publications, located in both the Ministry of Agriculture library (at the Research Division), or at Washington State University in Pullman. Photocopies are available on request from Pullman.

This report is divided into three major parts. The first is an executive summary (I-A), which is an overview of the Project, and includes a discussion of the farmings systems philosophy and approach. Also in the executive summary are summaries of 10 program areas (I-B), followed by very brief summaries of accomplishments and recommendations in those programs (I-C).

The second part of this volume (II) describes the agricultural situation in Lesotho at the time the project began in mid-1979, and is essential background for the more detailed program reports in Section III.

The editors are aware of the hazards of a document such as this being either too technical for some readers, or not technical enough, and thus not useful to other readers. We hope that the product is a useful balance.

Donald J. Lee
Team Leader,
FSRP, 1984-86

ACKNOWLEDGEMENTS

Condensing several thousand pages of material into a few hundred pages, and making it meaningful, is a formidable task that requires a team effort. The main contributors were those who generated the data--the expatriates and nationals who worked on the Project during its 7 years. I am especially grateful to those with whom I was privileged to work during my tour in Lesotho, January-June 1986:

- Dr. David Youmans, who shared his office and provided much support and encouragement.
- Dr. Donald Lee, Team Leader, who in addition to giving support and encouragement, was glad to share his expertise as a writer and editor.
- And to each of the other expatriate members whose cooperation in providing materials was so valuable as to make my job pleasant and much easier than it might otherwise have been: Drs. David Holland, Grant Richardson, Carl Goebel, Ray Brokken, and John Downes.

Special mention should also be made of the enthusiastic support of Trower Namane, Acting Director of the Research Division, and of the generous assistance given by Francinah Thabisi, Librarian. Others who made significant contributions were: Dr. B. Badamchian, David Granatstein, Elizabeth Kirby, and Mavuso Tshabalala.

In my view, those who deserve a special medal are the typists. am especially grateful to Ms. Mary Ann Tait, who worked over several hundred pages of very rough draft in Maseru, and to Ms. Mary Weitz in Pullman, who put the same material through several more typings into its final form.

Last but very high on the list is the general editor, Seth Beckerman, who transformed very rough material into a finished product that, we hope, readers will find very readable and useful.

A. I. Dow
Technical Editor

ACRONYMS

BASP	Basic Agricultural Service Project
BKB	Farmer Cooperative Brokers
CD	Conservation Division
FSP	Farming Systems Research
FSR/E	Farming Systems Research & Extension
FSRP	Farming Systems Research Project
GOL	Government of Lesotho
KASA	Knowledge, attitudes, skills, aspirations
LPMS	Livestock Products Marketing Service
MOA	Ministry of Agriculture
PA	Prototype Area
PCV	Peace Corps Volunteer
PMC	Produce Marketing Corporation
RAP	Reflective appraisal of programs
RD	Research Division
REA	Research/Extension Assistant
RSA	Republic of South Africa
SAMB	South African Meat Board
SAWB	South African Wool Board
USAID	United States Agency for International Development
VAC	Village Agricultural Committee
WSU	Washington State University

PUBLICATIONS IN SERIAL ORDER

Research Reports

Report Number	Title	Author
RD-R-1	Selection and Characteristics of Participants in Farm Records Program, 1980/81	Plath, J., Jobo, T.
RD-R-2	A Second Look at the Tentative Classification of Households in the Prototype Area	Plath, J., Tsiu, M. 1982
RD-R-3	1980/81 Crop Enterprise Budgets: Traditional Production Practices	Plath, J. 1982
RD-R-4	Seasonal Input Distribution Under the New Coop Lesotho	Wyeth, P. W.
RD-R-5	Pricing Food Grains and Pulses in Lesotho	Wyeth, P. W., Bostwick, D.
RD-R-6	1980 Nitrogen Fertilizer Rates and Harvest Frequency Response from Two Varieties of *Eragrostis curvula*	Tiedeman, J. A., Ramakhula, V. R., Ntsasa, R. M.
RD-R-7	1981 Annotated Bibliography of Range Related Research in Lesotho	Tiedeman, J. A. 1981
RD-R-8	List of Plant Species That May Have Potential for Lesotho Pasture or Range Seeding	Tiedeman, J. A.
RD-R-9	End of Tour Report, August 1979-August 1981	Tiedeman, J. A. 1981
RD-R-10	Forage Plantings at Libibing	Wieland, R. G.
RD-R-11	Molumong Store Forage Trials Report	Wieland, R. G.
RD-R-12	Final Report on the Training Course for Village Agricultural Committees, 29 Mar-30 Apr 1982	Matobo, T., Sefeane, A. S., Youmans, D.
RD-R-13	Final Report on the Training Course on Extension for Improvement of Farming Systems	Youmans, D., Sefeane, A. S.

Research Reports

Report Number	Title	Author
RD-R-14	Annual Report - Farming Systems Research Project	Ballard, J. C. 1981-82
RD-R-15	Final Report on Training Course on Professional Improvement in Agricultural Extension, 12-24 July 1982	Matobo, T., Sefeane, A. S., Trail, T. F., Youmans, D.
RD-R-16	Annual Report Agricultural Research Division, 1981-82	Research Division 1982
RD-R-17	Annual Work Plans for July 1, 1982 to June 30, 1983	Research Division
RD-R-18	Quarterly Report/Achievements July-September 1982	Research Division
RD-R-19	Quarterly Work Plans October-December 1982	Research Division
RD-R-20	Quarterly Report/Accomplishments October-December 1982	Research Division
RD-R-21	Quarterly Work Plans January-March 1983	Research Division
RD-R-22	Report on the Nutrition Course Held at Nyakosoba Research Center from 1st to 4th March 1983	Ramakhula, C.M.
RD-R-23	Report on Training of VAC's of Molumong at Mokhotlong F.T.C. on 14-18 March 1983	Tsiu, L.D.
RD-R-24	Report on Training Course of Chiefs of Molumong, Nyakosoba and Siloe at Matela Farmers Training Center 21-25 February 1983	Sefeane, A.S. Youmans, D.
RD-R-25	Agricultural Research Division Annual Work Plan, July 1983-June 1984	Research Division MOA
RD-R-26	Agric. Research Division Quarterly Report - Accomplishments January/March 1983	Research Division MOA
RD-R-27	Quarterly Work Plan - April/June 1983 Agric Research Division	Research Division MOA

Research Reports

Report Number	Title	Author
RD-R-28	Growing Pinto Beans in Lesotho: An Examination of Agronomic and Economic Considerations	Carvalho, J. Holland, D. Ballard, J.C. Van Epps, G. 1983
RD-R-29	1983 Crop Enterprise Budgets: Tree Fruits and Asparagus	Carvalho, J. 1983
RD-R-30	Farming Systems Research Conference for Field Workers 25-27 July 1983	Youmans, D.
RD-R-31	A Research Division Response to Subject Matter Specialists' Continuing Education Needs 1-5 August, 1983	Youmans, D.
RD-R-32	MOA/Research/Crop Research Section Annual Research Report July 1981-July 1982 Horticulture	Kotsokoane, M.M.
RD-R-33	1982/83 Crop Enterprise Budgets: Traditional and Improved Production Practices	Holland, D. Ts'Iu, M.
RD-R-34	Range Research and Development In Lesotho-End of Tour Report August 1979-October 1983	Tiedeman, J.A.
RD-R-35	Annual Report - Research Division July 1982-June 1983	Research Division
RD-R-36	Quarterly Report of Accomplishments (July-September 1983) and Quarterly Work Plan (October-December 1983)	Research Division MOA
RD-R-37	1982/83 Costs and Returns for Field Crops In Siloe, Molumong, Nyakcsoba: Results from Combination Farmers December 1983	Holland, D. Ts'iu, M. 1983
RD-R-38	The Role of Agricultural Research In Lesotho February 1984	Nts'ekhe, W.P.
RD-R-39	The Economics of Fodder Production As A Winter Crop In the Southern Lowlands of Lesotho March 1984	Holland. D. Ts'Iu, M. Klosterman, E.W.

Research Reports

Report Number	Title	Author
RD-R-40	Quarterly Report of Accomplishments October-December 1983 and Quarterly Work Plans January-March 1984	Research Division
RD-R-41	Quarterly Report of Accomplishments January-March 1984 and Quarterly Work Plan April-June 1984	Research Division
RD-R-42	Report on the Nutrition Course Held at Nyakosoba and Siloe Research Centers Siloe, 20-24 February 1984 and Nyakosoba, 7-11 May 1984	Ramakhula, C.
RD-R-43	Annual Report-Research Division July 1983-June 1984	Research Division
RD-R-44	Annual Work Plan for July 1984-June 1985	Research Division
RD-R-45	Report on Training Course for Farmers Summer Cropping at Nyakosoba and Siloe Prototype Areas, October 1984	Sefeane, A.S.
RD-R-46	Annual Report-Farming Systems Research on Lesotho July 1983-June 1984	Research Division
RD-R-47	Quarterly Report-Research Division Accomplishments July-September 1984 Work Plans for October-December 1984	Research Division
RD-R-48	The Extension Challenge: A Research Report on Ten Extension Schools for Agricultural Professionals In Lesotho, Nov 83-May 84	Youmans, D. Ramakhula, C.
RD-R-49	1983-84 Costs and Returns for Field Crops In Siloe, Molumong, Nyakosoba and: Results from Combination Farmers	Holland. D. Majoro, M. 1985
RD-R-50	Quarterly Report-Research Division October-December 1984 and Workplan for January-March 1985	Research Division
RD-R-51	Quarterly Report-Research Division Jan- March 1985 and Workplan for April-June 1985	Research Division

Research Reports

Report Number	Title	Author
RD-R-52	Report on Training Courses, Extension Workers and Subject Matter Specialists Technical Agriculture	A. Sefeane Sefeane Cecilia Ramakhula 1985
RD-R-53	Workplan July 1985-June 1986	Research Division
RD-R-54	Annual Report July 1984-June 1985	Research Division
RD-R-55	Quarterly Report of Accomplishments June-Sept. 1985 & Quarterly Workplan Oct.-Dec. 1985	Research Division
RD-R-56A	Report on SCECSAL VI. (copy not at WSU)	F. M. Thabisi
RD-R-56B	Report on Practical Course in Library Technical Operations (copy not at WSU)	F. M. Thabisi
RD-R-56C	Report on the 3rd Technical Consultation of CARIS (copy not at WSU)	F. M. Thabisi
RD-R-57	On-Farm Agronomic Research Results (copy not at WSU)	G. Richardson T. Namane M. Mofoko S. Moima E. Scherin C. Brunetti
RD-R-58	Oct-Dec 1985 Quarterly Report (copy not at WSU)	Research Division
RD-R-59	Jan-Mar 1986 Quarterly Work Plan (copy not at WSU)	Research Division
RD-R-60	Costs and Returns for Commercial and Semi-Commercial Orchards in Lesotho: Apples, Peaches & Pears (copy not at WSU)	Amman Snir David Holland
RD-R-61	An Extension Short Course for District Agricultural Officers, Proceedings, Finding, & Recommendations	David Youmans Abraham Sefeane Edward McCombs 1986
RD-R-62	Pest Control for Vegetable Crops in Lesotho: Cost & Related Info.	Sheila Woods Molapo Qhobela D. Holland 1986

Research Reports

Report Number	Title	Author
RD-R-63	Report on Sarccus Sub-committee Phytosanitary Control held at the Quarantine Station Stellenbosch Cape Town, Apr. 14-18, 1986	M'athotoane Ramasike
RD-R-64	International Workshop on the Role of Applied Research in Agricultural Development held in Israel from Feb. 11-Mar. 5, 1986	A. S. Sefeane

Research Bulletins

Report Number	Title	Author
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PROJECT PERSONNEL*

Administration

Expatriate Team Leaders
- Robert O. Butler
- J. Clark Ballard
- Donald J. Lee

Nationals
- W. P. Nts'ekhe, Director
- S. B. Mkhize
- S. Ntlaloe
- M. Matli
- T. Namane
- M. Ntoanyane
- Francinah M. Thabisi, Librarian

Rural Sociology

Expatriates
- Lorna M. Butler

Nationals
- Nthope Mapefane
- Thope A. Monakeng
- M. Tshabalala
- Thope Matobo

Farm Management

Expatriates
- Joel C. Plath
- David Holland

Nationals
- A. S. Sefeane
- L. D. Ts'iu
- M. Ntoanyane
- T. Jobo
- H. Letsie
- M. Tshabalala
- J. M. Letsala
- B. Mokhachaue
- K. Makhabne
- M. Ts'iu
- M. Majoro
- P. M. Alotsi

Graduate Students
- Bonnie Borris
- Joe Carvalho

Soils

Expatriates
- B. Badamchian

Nationals
- P. Namane
- M. Mafolo

Agronomy

Expatriates
- Alvin G. Law
- Gordon H. VanEpps
- Keith E. Wallace
- G. L. Richardson

---

* More complete listing and times of service can be found in Section III-A, Administration.

Nationals

Trower Namane	F. Nkuatsana
M. M. Kotsokoane	P. Namane
J. N. T. Peshoane	D. T. Maboee
S. D. Mtsambine	E. Mafoko
B. N. Ndimande	E. Pomela
I. M. Mots'oane	S. S. Moboee

Graduate Students

Elizabeth Kirby	David Granatstein

Plant Protection

Nationals

M. Qhobela	M. Ranasike
T. Lepheana	

Horticulture

Expatriates

J. Clark Ballard	J. D. Downes

Nationals

M. Kotsokane	S. Sekoli
M. Mots'oane	

Range Management

Expatriates

James Tiedeman	Carl Goebel

Nationals

Victor Ramakhula	M. Mabusa
M. Manoto	G. Seutloali

Graduate Students

Ron Wieland	Allen Dobb

Animal Science

Expatriates

Earle Klosterman	Donald J. Lee

Nationals

Molemo Molapo	M. Motselabane
L. Mohapi	M. Moleko
T. Matoane	K. Mohlakoana
E. Mokheseng	

Marketing

Expatriates

Emer E. Broadbent	Ray F. Brokken
Peter W. Wyeth	

Nationals

N. Moletsane	M. Motsamai

Extension

Expatriates

Seth R. Beckerman

David V. Youmans

Nationals

A. Sefeane

M. Ntoanyane

L. D. Ts'iu

H. Letsie

C. Ramakhula

THOSE WHO PREPARED THE REPORT

FS/FSRP	D. V. Youmans
Situation Before 1979	A. I. Dow
<u>Program</u>	
Administration	D. J. Lee
Rural Sociology	A. I. Dow and M. Tshabalala
Farm Management	D. W. Holland
Soils	A. I. Dow and B. Badamchian
Agronomy	A. I. Dow and G. L. Richardson
Horticulture	A. I. Dow, J. D. Downes, Elizabeth Kirby, and David Granatstein
Range Management	A. I. Dow and C. J. Goebel
Animal Sciences	D. J. Lee
Marketing	R. F. Brokken
Extension	D. V. Youmans, Abraham Sefeane, and Cecilia Ramakhula
Technical Editor	A. I. Dow
General Editor	Seth Beckerman

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I. Executive Summary

A. Farming Systems and the FSR Project

During the late 1970s it became clear to many workers in international development that programs designed to help farmers in developing countries often failed to have a lasting impact. Investigations into the failure to introduce beneficial, lasting change into the farming practices of peasant and subsistence farming communities identified several contributing factors. Those factors under the influence of agricultural development projects were:

- the tendency to use too many resources which farmers could not generate;
- attempting to transfer technology used by commercial farmers with access to a variety of inputs, including credit, to small-scale farming operations;
- the failure to consider the farmers' cultural and economic constraints in adopting different technology; and
- the lack of adequate training programs to compliment the attempted introduction of new technology and production methods.

The result of many of these projects, although successful when expatriate advisors and donor resources were available, was for the local residents to consider them "theirs". Because the local farmers were not involved in the design and implementation of research and development projects, they did not understand, or particularly care, how project activities were conducted. When the project terminated, the farmers went back to their traditional methods. In some cases, the projects did considerable harm by encouraging people to give up certain traditional methods without replacing them with improved technology that was realistic for their circumstances.

Lesotho had experienced some projects with the shortcomings described above, and when the Farming Systems Research Project was designed in 1978, an attempt was made to prevent a repeat of former failures, and to involve cultural and sociological aspects, as well as economic and biological factors. Since the design and initiation of the FSR Project, there has been a large increase in the literature on the subject that is referred to as Farming Systems Research. The concept of involving the farmer and considering his/her economic and cultural situation in development projects has been debated and discussed by many workers during the last 7 years, but there are still disagreements about FSR methodology. Few other FSR-type projects have covered the scope of activities that were included in this project.

1. Farming Systems

Shaner et al. (1982) define farming systems research and development (FSR & D) as "an approach to agricultural research and

development that views the whole farm as a system (and) focuses on (1) the inter-dependencies between the components under the control of members of the farm household and (2) how these components interact with the physical, biological, and socio-economic factors not under the household's control".

Farming systems research procedural components are (1) target and research area selection, (2) problem identification and development of a research base, (3) planning on-farm research, (4) on-farm research and analysis, and (5) extension of results.

Watts and Claar (1983) view farming systems research, as currently supported by USAID, as a major conceptual breakthrough in farmer-oriented agricultural research. Nobe (1983) sees FSR as a prototype managerial organization for agricultural development, as opposed to patronistic and administrative types, and thinks the specified results feedback mechanism is a major strength of the FSR approach.

FSR as a viable strategy for research in developing agriculture in South Africa is introduced by Van Rooyen (1984). He singles out the farmer as the central figure in applied farming systems and thus a vital partner in farming systems research. He stresses its complementarity to traditional research but feels FSR can best take into stride the abilities and attitudes of farmers. Van Rooyen describes the essential steps of FSR as (1) description, (2) design, (3) test, and (4) extension. He feels that the interaction of forward and backward linkages between researchers and farmers is its great strength. By studying farm conditions in uniform environmental and socioeconomic areas, FSR is able to develop recommendations which are applicable throughout such "domains". Another strength of FSR, according to Van Rooyen (1984), is its reliance on multidisciplinary teams in the study of expanding on the notion of "domains", as the framework for on-farm research. Since the objective of FSR is to produce recommendations for farmers, then such recommendations should be reliable over a recommendation domain consisting of farmers whose farms and practices are similar, and who farm within a uniform agroclimatic zone.

In further description on the nature and dynamics of farming systems research, Shaner et al. (1982) say that FSR can be summarized as being "farmer based, problem solving, comprehensive, inter-disciplinary, complementary, iterative, dynamic and responsible to society".

FSR researchers keep farm conditions in mind and intergrate cooperating farmers in on-going research into solvable problems. FSR team members from a variety of relevant disciplines work together to study all components affecting farmers' lives, and the interrelationship of these components. Such studies complement basic research and the findings of other concerned organizations. FSR researchers use their findings to update their understanding of the farming systems being studied and modify further study accordingly.

Dynamics are important in FSR as small modifications may lead to subsequent major changes, being at all times responsible to both local farmer groups and society at large.

Hildebrand (1984) suggests that scientists who work on interdisciplinary farming systems research teams must have genuine interest in the disciplines of other team members, and be willing to accept observations and suggestions from collaborators outside their respective disciplines. They need to be flexible and willing to modify field techniques to accommodate the interdisciplinary approach. Farmers must be fully integrated into field research for the FSR spirit to fully prevail, and for the entire team to appreciate farmers' views on their own constraints. The farmer must be the prime client for FSR to make sense and for farm problems to be solved in a prompt and realistic way.

While researchers look at problems in an academic way, Hildebrand warns that farmers are concerned with the urgency and survivability of their livelihood. He thinks FSR team members must feel this sense of urgency in solving farmers' problems in order to be credible among their principal clients. While FSR developed on three continents under independent conditions, there is now general agreement as to its "essence" and its field methodology. Surveys must be quick, relying a great deal on the cumulative knowledge and wisdom of farmers. FSR researchers must work with available resources and not waste time on wishful thinking.

Rose and Tapson (1984) adopt an FSR approach with respect to the problems of agriculture in developing countries and as an operational strategy for the University of Fort Hare's small-farm systems research activities in Ciskei. The authors recognize the frequent and frustrating fact of life for agricultural development workers--the nonacceptance by farmers of innovations developed for their benefit. Much of the technology researched and recommended for small farmer use remains largely ignored, according to these authors. They liken the problem of nonadoption in Africa to large parts of the rest of the developing world. Among the phenomena blamed for nonadoption are lack of inputs, lack of roads, poor markets, ineffective extension services, and insecure land tenure systems. Prescriptive agricultural development schemes in Africa have largely failed.

Rose and Tapson (1984) espouse the Cornell University approach to agricultural research used in Ecuador. In so doing, they accept the premise that the most severe deterrent to peasant adoption of agricultural innovation is that so much of the technology developed is inappropriate to the conditions of the small farmer. Rose and Tapson promote an FSR concept involving (1) understanding farmers and their practices, (2) identification of farmers' problems and priorities, (3) isolation of constraints to productivity, and (4) selection through on-farm experimentation of improved technologies.

Small farm development in the emerging world requires a shift in research and extension thinking, according to Harwood (1979). He

writes about those aspects of small farm production systems which lead to efficiency under limited resource conditions. A mix of traditional and more advanced technologies is usually called for in breaking the productivity barrier. Harwood proposes collaborative work among researchers, extension workers, and farmers in this respect.

Small farmers resist accepting change because of having inappropriate technology recommended for their adoption, writes Hildebrand (1981). He does not believe the problem is one of motivation. Appropriate technologies constitute a challenge for researchers because agro-socioeconomic conditions of small farmers are highly location specific. Small farmers do not react favorably to technologies developed for commercial farmers. He proposes that multidisciplinary teams live and work closely with farmers in order to jointly conduct research and develop problem-solving technologies. Such a research mode, on the part of the scientists, represents a departure in the work norm.

Thus can be seen that farming systems research has become a major strategy throughout the developing world. It engages the farmer as an active partner at the very outset in the identification of agricultural problems and concerns as seen through farmers' eves and in the context of their "world". It then retains the farmer as a proactive "colleague" in on-farm research. He or she becomes one of a team of problem solvers who probe and test ideas, promising alternatives, and technologies on farmers' fields. At any time in this process, the farmer may accept, reject, or modify an idea based on constraints identified from the farmer's point of view. Importantly, the farmer is meanwhile sharing the cost of intervention and change.

The theory behind the strategy, among other things, holds that if farmers have an active role in sharing with researchers their rationale for doing things their way, in identifying their own problems as they see them, in trying alternative solutions and changes on their own land at certain costs and risk to themselves, then results of that exercise will have a much higher probability of widespread adoption than have the results of the more traditional "top-down" recommendations of common experiment station research. Farming systems research as a development strategy is not intended to replace experiment station research, but complement it in a highly dynamic and realistic manner (Youmans, 1984).

2. Farming Systems Research Project

The FSR project in Lesotho had as its principal goal to improve rural life by increasing the incomes of Basotho farmers. The project worked toward the creation of farming systems as rural enterprise mixes designed to improve farm productivity. Although largely directed toward on-farm research and institution building, emphasis included finding the most appropriate means of transferring knowledge and gaining farmers' acceptance of recommended technology through extension. The project is farmer-centered in that recommendations

must be acceptable to farmers, sensitive to their management capability, appropriate to their resources, and protective of Lesotho's badly eroded land base (USAID, 1978, p. 4).

While agriculture is the most important sector of the gross national product of Lesotho, farmers do not readily adopt innovative and potentially productive farming practices. Keeping in mind the lessons learned about the "appropriateness" of recommendations, the FSR researchers and extension practitioners aimed research toward the development of reasonable enterprise mixes, problem solving in the area of farming practices, and innovations which are feasible and affordable. This work was done together with cooperating farmers and members of village agricultural committees, with a goal of 5% adoption by project end in 1986.

Inherent in FSR activity was on-farm research and adaptation of results to Lesotho farm conditions, building a national agricultural research capability within the Ministry of Agriculture and Marketing, and investigation into promising extension methodologies for transferring appropriate technologies and gaining farmers' acceptance, (Lee, 1985, p. 1).

Expatriate personnel deployed to Lesotho by Washington State University in long-term advisory roles included administrators, farm management economists, a social analyst, agronomists, an animal scientist, marketing economists, range management specialists, a horticulturalist, a communications/information specialist, and an extension educator.

Lee (1985, p. 3-5) points out that Farming Systems Research (FSR) is fully integrated into Research Division activities. Agronomy and Horticulture Sections tested new varieties of crops and seek cultural practices best suited to local conditions. Soil and Plant Protection Sections complement these activities with expertise and recommendations. Farm management personnel, cooperating with other sections, develop production enterprise schemes based on FSR principles. Marketing officers study market systems for livestock and crops and make recommendations to farming communities. Animal Science and Range Sections work together toward sound but affordable animal management practices and recommendations protective of soil and natural vegetation resources. Lee explains that "the Extension Section holds farmer training sessions, schools for extension field personnel, interacts with Village Agricultural Committees, and prepares radio programs and extension circulars on a year-round basis. Field days are held in conjunction with the cropping season" (Lee, 1985).

This inclusion of an extension component was a unique feature of the FSR Project. The involvement of Extension Section personnel with both researchers and farmers provided a mechanism for the flow of information to and from the user. The inclusion of a marketing component in the project was also somewhat unusual for a FSR project and provided the capability to study off-the-farm factors that had a direct impact on production practices.

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B. Program Summaries

Conclusions and recommendations from each of the ten program areas are summarized below, including a general statement about how the results may affect future projects, programs, and policies of the Ministry of Agriculture and the government of Lesotho.

1. Administration

a. Institution Building and Program

The beginning of the FSR Project corresponded with the formation of the Research Division in the Lesotho Ministry of Agriculture. Both were started in 1979 and have existed as essentially a single program since 1980. The FSR Project has funded and supported many of the Division's programs since it was formed, and some younger staff members have had FSR Project support for all their professional careers. The support received from the project has enabled the Research Division to advance toward becoming a mature research organization, but it is only a beginning. Much must be accomplished before the long-term goal of a Ministry research organization capable of meeting the country's needs is realized. Some of the necessary organizational and physical structures are in place and functioning, while others are not yet established, or are in their initial stages. The problems and constraints of the young Research Division are common to many agencies and organizations during their formative stages and do not represent unusually formidable obstacles. However, continued support and guidance will be essential for future development.

Training 20 nationals to B.S. or M.S. levels has been a major accomplishment of the project that will have a lasting impact on the country. This long-term degree training, together with the short-term training program, enhanced the capability of the Research Division staff many-fold. These returned trainees, along with the facilities constructed during the last 7 years, have provided a nucleus for developing a viable research unit. But it is only a beginning. The number of people with advanced degrees is far fewer than what is required for a strong, active research program capable of meeting Lesotho's needs. In addition to B.S. and M.S. degree holders, there is also a critical need for trained support personnel, especially field and laboratory technicians.

In order for continued development of the Research Division, the administrative process must mature and change to meet new situations in the same manner as the technical programs. The administration and management of the Division have been carried out almost exclusively by the Director's office with a minimum of input by Section Leaders. Administrative affairs such as budget preparation, allocation of resources, upkeep and maintenance, and personnel matters at all levels were handled by the Director or Deputy Director. Section Leaders did not have an active part in making decisions that affected their daily activities and programs. This system contributed to the frequent failure of an administrative decision to be implemented. As more

staff with advanced training return to the Division, this undesirable situation will become a larger concern. The present Acting Director, Mr. Trower Namane, is taking steps to remedy this situation and is involving senior research officers in decisions about Divisional matters. The staff now feel more a part of the total organization, and responsiblility and authority are placed closer to the action. Some management changes that need to take place within the next year to encourage the development process are:

- A written policy and regulations statement for the Division should be prepared with input from all Sections. This document should cover such items as the chain of authority, the responsibilities of the different levels of the staff from laborer to Director, procedures for conducting Divisional affairs, and how disciplinary matters should be handled.

- A committee should be formed to make management decisions about operating the research farm and substations. A qualified person should be appointed as Farm Manager and be a member of the committee. The Chairman of the committee should be responsible for supervising all aspects of the farm, e.g., weed control, cleaning unused plots, assignment of plots to researchers, security, and maintenance of fences, roads, and equipment.

- A budget/program meeting should be held annually prior to the cropping season. Each section would present detailed plans of its program for the coming year, state the objectives of each activity or trial, and provide an estimate of needed resources. Such a procedure would: a) help unite the Research staff by providing them with the opportunity to participate in the budget-making process; b) provide the Director with a well substantiated budget request to present to the Ministry and other GOL bodies; and c) stimulate the researchers to analyze their programs carefully before they start trials, surveys, joint Research/Extension activites, etc. This will increase the effectiveness of research funds.

- The Director's Office, or an appointed member of the Research staff, should actively seek sources of research funds for the Division. International centers, FAO, EEC, consortia of African countries, and other such organizations are potential sources of grant funds to support research. These should be pursued more vigorously than in the past. Returning degree holders will provide Research with needed capability.

b. External Relationships

The value of research to a society is judged by the contributions it makes to further the well-being of citizens in that society, and agricultural research in Lesotho is no exception to this basic evaluation measurement. The Research Division is in a sense a service organization that was formed to provide information and knowledge to a wide range of users. Thus, the Research Division must have an ongoing

exchange of information and ideas with all its clientele groups, which include farmers, other divisions in the Ministry, and MOA administrators. Interactions with international centers, many different donor organizations, and consortia made up of African countries such as SARCUS, are an important part of the overall research program. The necessary relationships have been established to varying degrees, but some need to be strengthened.

Continual interaction with other divisions in the Ministry is critical to the development and growth of the Research Division to ensure research concentrates on problems that the service and production-oriented divisions encounter in their programs. It is also needed to build an acceptance of the young Research Division by the rest of the Ministry and to form genuine cooperation between researchers and the personnel in ther divisions. To date, these essential relationships have been formed to only a limited degree. Cooperation and harmonious relationships require positive attitudes on the part of all involved parties and the Research Division can not establish the desired interactions by itself. Some steps the Ministry could take to encourage better relations between Research and other divisions, and among other divisions as well, are:

- Prepare a written document that clearly defines the three functions of the Ministry, service, extension, and research, and which establishes the responsibility for each within the Divisions. This would help eliminate the fear that another Division might take over certain parts of a particular division's program and help each Division concentrate on fulfilling its established and known duties.

- Conduct annual Ministry meetings in which each Division reports on its activities. During the 2-year extension of the FSR Project, very little information has been exchanged between the Research Division and other Divisions in the Ministry, with the exception of Extension. Personnel from other Divisions on occasion have expressed little knowledge about the Research program or how it relates to their activities. In one case, distrust for researchers on the research program was very clearly voiced. This attitude was apparently created by lack of knowledge about the program and misunderstanding about Research's interest in their activities.

- Increase the support for Research. The Division is underfunded and poorly supported at the present time. The financial situation in the country is recognized, but without additional support, Research cannot develop into the capable organization needed to serve Lesotho's agriculture. Some assistance would cost the Ministry very little, e.g., personnel trained by the FSR Project under an agreement with the MOA who are committed to a certain time at the Research Division should be transfered as soon as they return from school. People with degrees should be paid accordingly, not at their former salaries.

- Develop country-wide priorities for agricultural development with input from all the Divisions in the Ministry to ensure the proposed plan is supported by sound data and approved by the people who will carry out the program. Programs designed from the "bottom-up" are usually founded on a realistic appraisal of the situation, and are normally supported by personnel implementing the program because they had a part in its design. This is often not true of programs that are "top down".

Implementation of these four actions would improve the relationships among all the Ministry's Divisions, and would help Research develop into a respected and recognized Division with a program understood by other MOA personnel, which meets the needs of the country. Such an arrangement would also help the Ministry coordinate the efforts of the many donor and GOL agricultural projects active in the country.

c. Program Accomplishments

The FSR Project has succeeded in achieving most of the goals identified in the project paper. Some, like the establishment of a FSR Section in the Research Division, were abandoned and replaced by other approaches for reaching the project's overall objectives. Project activities have resulted in:

- A better understanding of deficiencies in traditional production practices and how cultural and economic factors influence the acceptance of technologies proposed to overcome these barriers. The goal of adoption of a new technology by 5% of the prototype area farmers was surpassed. The willingness of farmers to put their own money into improved technology and new practices is evidence of their interest in increasing production and income.

- A publication series for the dissemination of research results was established. Bulletins, reports, and circulars are routinely sent to relevant offices and organizations. Handbooks are prepared, revised, and disseminated as needed.

- Interaction with international centers such as CIMMYT and ICRISAT is occurring on a continual basis and agronomists are cooperating in a sorghum and maize testing program with scientists from these centers.

- Work in the three prototype areas has resulted in an understanding of the limitations and characteristics of each of the major ecological zones in the country.

- Pitsos, training schools, radio broadcasts, and demonstration field days have been used to transfer information to farmers. An in-depth analysis of the results indicates a marked impact on the knowledge, attitudes, skills, and aspirations of farmers involved with a sustained Extension training program. The incidence of practice changes also increased among participants.

- The goal of sending 16 nationals for long-term degree programs was surpassed, and short-term training for others was a continuous part to the FSR Project program.

- The Agricultural Research Library has developed into a well-organized repository that serves the needs of many agencies in Lesotho. It has already outgrown its physical facilities.

Areas where progress has been disappointing, or slower than desirable, are in getting increased support and recognition for the Research Division from MOA administrators and other Divisions, and in establishing a solid research capability in the Division. There is a shortage of research leaders who are capable of designing and implementing successful programs in the various disciplines, capable support personnel are not available, and the attitude and dedication found at all organizational levels in top quality research units has not yet developed. However, there is no reason to believe that these essential qualities won't develop if the proper administrative guidance is provided and the Division receives the necessary resources.

2. Rural Sociology

The Rural Sociology Section has not been consistently active throughout the 7 years of the Project. The only expatriate was Lorna Butler, during 1979-81. The program continued on a limited scale under the leadership of Thope Matobo until her departure to WSU to begin graduate work in 1984, and then resumed under M. Tshabalala in early 1985 until the end of the Project.

a. The Baseline Survey

A major contribution to the Project and perhaps the most significant activity was the development and implementation of the Baseline Survey. The methodology for that activity was published by Butler (1982), in which she listed the purposes:

- To provide a quantifiable description of prototype area farming practices within these interrelated categories: family structure, livestock, range, crops and farmland, farm inputs, marketing, extension and information, and family nutrition.

- To provide a current description of prototype areas population by describing, on a sample basis, the social structure of area households.

- To identify social, economic and technical constraints in increased farm production and income, thereby contributing to future MOA Research Division program directions.

- To identify better methods of providing agricultural technical information to farmers.

- To create an on-the-job training laboratory in field survey methodology for Research Division personnel.

- To increase prototype area farmer involvement in, and understanding of, Farming Systems Research.

The data collection model had to accomodate some immediate needs. It had to allow for multidisciplinary collaboration to meet the requirements of the integrated farming systems mandate. Past agricultural projects frequently limited their focus to technical aspects of production, overlooking the sociological, cognitive, and political constraints to production. The approach had to provide a quantitative basis from which the Research Division could objectively and reliably generalize to comparable farming situations. Lesotho's diverse ecological environment has precipitated a wide variety of farming systems. Limitations of existing data make it extremely risky to make nationwide inferences and predictions. The FSR Baseline Survey was conducted using the personal interview technique and a structured Sesotho language questionnaire.

The survey covered seven general subject areas. The questionnaire for each was quite detailed. Following are the general subjects with some examples of subtopics:

General Family Description. Who is the head of the household? List members of household, educational level, age, residents, marital status, for each member.

Livestock. Livestock inventory: types and numbers of animals, livestock problems, feeding, draught animals.

Crop Production. Land tenure, crops grown, crop problems, fields and field use, production estimates, fallowed fields, seeds and germination, weed control, fertilizers, varieties, pest control, storage.

Farm Inputs. Labor and labor problems, physical inputs, seed, fertilizer, equipment, ox-drawn or tractor drawn.

Marketing. Sale of farm produce, marketing problems, prices, which crops sold (maize, sorghum, etc.), animals sold, household income.

Extension and Communication. Extension agent: do you know him? From whom do you get your information? Radio: do you have one, is it helpful? Preferred sources of information.

Human Nutrition. Buying and cooking - who makes decisions, food aid (donated food), food as payment, infant feeding (breastfed?), child's first foods, diet history, sources of nutrition information.

b. The 1981-82 and 1982-83 Reports.

(1) Village Agricultural Committee Training

The primary function of the committee members was, in a leadership role, to serve as another vehicle for education and information dissemination throughout the village farming community. The results of this work are given in five typed/duplicated reports written during 1981-82.

Village Agricultural Committees' Training, July-August 1981. Objective: Determine what kind of people researchers are working with so that decisions could be based on the appropriate level and required needs of the people. Interviews provided a profile of the VAC members.

The members of the Village Agricultural Committees (VAC) in the three prototype areas are middle-aged men and women. Almost all are married and live in the same villages all the time. Only a few spouses live in other areas while in search of work. They come home at certain times but not necessarily in the plowing, planting, or harvesting season. Their educational level is not very high, but they can read and write. Even then, they should not be overburdened with written material. Demonstrations and verbal communication are recommended instead of written material.

They have access to land for fields and gardens. This makes it easier for them to practice what they have been taught during the training course. They have livestock which can be improved by growing and feeding fodder. Apart from livestock these people have special skills which can help them earn money with which they can buy agricultural inputs to improve their food production.

Evaluation of VAC Training, March-April 1982. This study was to determine if the previous course had any impact, if VAC members now practiced some things they were taught, and whether they understood their role. It was determined that they did. They were beginning to be aware of the importance of organic fertilizers such as kraal manure, ash, and compost, and were using them. More people knew about inorganic fertilizer, although some still did not use any fertilizer. Of those who grow fodder, barley was planted by the majority, followed by oats. Very few grew lucerne. The farmers were prepared to spend more money to buy recommended improved seeds in order to improve their production. In this case, the members will set an example to the other farmers, thus passing along the agricultural information. It is only if they know what they have grown that they can compare the germination, growth, and maturity of each of the varieties they have planted. Twenty of 47 started culling livestock. The general conclusion was that "On the whole we can see that the group formations are important and we should work toward improvement as they have shown courage and enthusiasm. We have chosen good channels for converying our messages."

VAC's Attitudes on Selected Farming Practices. The farming practices listed by most Committee members as important for high maize production include using improved varieties; 65% of participants from Siloe, 78% from Nyakosoba and 57% from Molumong said improved varieties were important.

Another farming practice that was listed as important was autumn plowing. In Siloe it was listed by 62%, 39% at Nyakosoba, and 43% of the Molumong participants. Keeping weeds cut until maize has reached the right height was listed as important by 61% of the participants from Molumong, 38% at Siloe, and 36% at Nyakosoba.

In all three prototype areas 75% of the participants said they plowed their fields in the autumn. The most common reason among those participants who said that they did not plow their fields in the autumn was that oxen are not available at this time of the year.

Commercial fertilizers were used by 25% of all the participants in the three areas. One of the major reasons listed for not using commercial fertilizer was that the participants did not know how to use it.

Generally, the three main practices identified as most important for timely planting were: growing special oxen feed, reserving special pastures to feed oxen, and having stronger oxen. Each of these three practices indicates that the major hinderance to timely planting is the fitness of oxen for any heavy work at this particular time of year. Participants said that strong, well-fed oxen do their work faster and better than weak, malnourished ones. This means that oxen owners can plow their own fields and still release their own oxen for hire. Also strong oxen can be used at any time of the year, even when grass is scarce.

Very few people from Siloe (5%) and Nyakosoba (14%), said there was enough grass for their livestock. On the contrary, 61% of the participants from Molumong admitted that grass at the area was quite adequate for their livestock. It is interesting that the number of people who believed there was enough grass for the livestock increased with the increased altitude of the prototype areas. Of the participants who said there was not enough grass for their livestock, 49% believed that the problem could be solved by enforcing rules against trespassing in cattle pasture areas. Also, 41% thought that rotating animals to rest grass at village pasturelands could solve the problem.

The participants were asked to show which of the listed circumstances would persuade them to sell more of their cattle. Most of the participants from Siloe (62%) said shortage of grass fodder would persuade them to sell more cattle, while 64% of the Nyakosoba participants indicated that they would sell more cattle if they needed more money, and 87% of the Molumong participants said higher cattle prices would persuade them to sell more cattle.

The situation where a buyer has a lot of money and needs maize badly was the most important one under which many participants, from all three areas, felt they could ask for higher rather than lower prices for their maize. The other situations which many participants felt would lead them to ask for higher maize prices were: when shops are selling mealie meal at a high price, when the village is a long way from shops and your neighbors have no maize to sell, when the individuals concerned and other farmers have a very big maize harvest, and when very much in need of money and a few people want to buy maize.

In general the three main reasons to grow maize, sorghum, peas, beans, and wheat as listed by participants from the prototype areas are to provide food for families, to provide food for animals, or to sell or trade. By growing these crops as animal food, the participants meant that after harvest their animals feed on crop residues, particularly in winter when grass is scarce. In a few cases however, they indicated that when their maize crop is still green, they sometimes cut it and leave it to dry, and finally feed it to their animals. They said they often do this when their maize crops fail.

Training VACs: Value Study. The purpose of a values test was to help both the Research Division staff and FSR colleagues to better understand the participants' attitudes. These values may affect farmers' attitudes or behavior towards certain agricultural aspects. Knowledge of these would also facilitate communication between Research staff and the farmers.

The test was divided into Set A, instrumental values; and Set B, terminal values. Examples of instrumental values were: Ambitious, Broadminded, Capable, and Influential Speakers. Examples of terminal values were: Happiness, True Friendship, a Sense of Accomplishment, and a Village at Peace.

In Set A, Ambitious scored first in Siloe, and second priority in Nyakosoba. Intelligent scored either as first or second priority in the three areas. To Own Much Livestock was the least important, 24th priority, in the three areas.

In Set B, Salvation was the highest priority in all three prototype areas. It was followed by Wisdom in both Nyakosoba and Siloe. A Comfortable Life scored as the least important priority in this set of values.

c. Using Horses as Draft Animals, Thope Matobo, 1982

The sociological problems encountered in disseminating the idea of using horses as draft animals was investigated. Two projects had already established the advantages of using horses over oxen. It had been demonstrated that horses were stronger, faster, more durable, and easier to feed, and thus more efficient.

Social prestige did not hamper the use of horses for draft power. It "does not lower the prestige of the owner, instead it increases his status in society as he can complete work in his fields quickly ... he is honored for that". "Farmers no longer think about prestige but about their stomachs."

In short, "it is not very difficult to get the farmers who have horses to use them in field activities if a tractor is available."

d. Rotational Grazing, Nyakososba/Ha 'Mokele, July 1981

Rotation and grazing control is 8 years old in this village. Farmers have some experience, and is important to take advantage of this experience. Their opinion would be important to develop the grazing and rotation pattern.

There is a lot of democratic cooperation within the village which should be encouraged so farmers are able to solve their problems. During data collection there were concerns about certain problems, which the villages thought were for the MOA to solve. But the Research Division staff pointed out these problems were for them to solve.

Range and Extension staff should keep in close contact with 'Mokele village to understand the nature of the problems and act in time to help resolve them.

The new rotational grazing system was started in one of the smallest villages in the prototype area. Larger villages developed some jealousies. Consideration was given to expanding the program to include all villages under one Area Headman. 'Mokele enjoyed sharing rights with its neighbors, but the 'Mokhele grazing area is not sufficient to cater to 'Mokhele animals only through the year. Range and Extension needed to start an intensive education program in neighboring villages about range rotation to help solve grudges and jealousy problems with other villages.

There needs to be a record system of all activities by the Research staff, such as meetings held and discussion topics, peoples' views and attitudes, rotation dates, and livestock movements into various camps, etc.

In an evaluation a year later in July 1982, livestock owners were asked if the program was successful, and what were some of the problems. In general livestock owners thought the program was successful, although some had reservations.

c. Implications

Sociology is the study of behavior of people in a community. It is heavily involved with social structure and with how people think and feel. In order for the farming systems approach to be effective, it was important that the Basotho rural society be examined within

this context. It is only from this base that we could begin to understand the Basotho and why certain farming practices were followed. And it was only from this base that work toward the goal of an "improvement in the quality of rural life" could progress.

The Rural Sociology Section could be effective only by working in close cooperation with the other Sections. This was done very effectively in the first and most important endeavor, the Baseline Survey. It was important, for example, to find that some of the agronomic practices which may have seemed strange (and "wrong") to an expatriate, had an explanation that was understandable, even if not technically or economically correct. Thus the production units were able to operate much more intelligently from that data base.

The other activities of the Section, described previously, while very different from the Baseline Survey methods and results, were similar in philosophy and general approach. A significant amount of data was collected on what the practices were and why.

The extreme importance of trying to understand people before working with and for those people has been amply demonstrated within the Project.

A Baseline Survey is an essential part of the Farming Systems approach. In view of this, the following are recommended:

- Conduct an informal survey within the first few months as a basis for making programming decisions. The survey is done quickly in order that programming not be delayed. Obviously the data will be preliminary and conclusions may need to be modified.

- Conduct the formal Baseline Survey within the first year of the Project and make useful adjustments in programming.

- During the last year of the Project, conduct a scaled down version of Baseline Survey in an attempt to measure any behavior changes.

3. Farm Management

The Farm Management Section investigated the economics of Lesotho's agriculture. Particular attention was given to production rather than marketing. The research reports of the Farm Management Section may be divided into four major categories:

- the historical and economic development of agriculture in Lesotho,

- the costs and returns of agricultural enterprises in Lesotho,

- the financial results of the "combination farmers" program, and

- the test results of new agricultural technology.

This summary is a brief outline of these components of farm management research in Lesotho, and will review the main research reports and bulletins associated with each component. Interested readers will find additional information in Section III-C, and of course in the reports and bulletins themselves.

a. The Agricultural Setting in Lesotho

Agricultural development in Lesotho today is influenced by the culture and traditions of the Basotho as well as Lesotho's unique position and relationship with South Africa. Crop farming in Lesotho is characterized mainly by small (2-3 ha) subsistence farms. Very little crop production is sold. In the prototype research areas, for field crops such as maize, about 3% of total crop production was sold (Holland, 1983, RD-B-14, p.25). Agricultural productivity (both labor and land) was low.

Because of the historical development of Lesotho's agriculture, it was important to better understand the social and economic differentiation which characterizes rural society as a guide to more intelligent agricultural research and extension procedures. In that respect, the most important work was the Farming Systems Baseline Survey conducted in 1980 under the direction of the Rural Sociology Section in the Research Division. A 15% random sample of rural households was surveyed in the three research prototype areas, Siloe, Molumong, and Nyakosoba. The survey asked questions about social, economic, and biological aspects of agriculture in Lesotho.

The Baseline Survey is the foundation for three Research Division publications from the Farm Management Section. Aspects of economic differentiation and agricultural commercialization in Lesotho's agriculture were examined in RD-B-14. A review of agricultural problems as identified by respondents to the survey was provided in RD-B-20. Finally, the classification of Lesotho's rural population into target groups based on economic and social criteria was discussed in RD-B-46.

b. Enterprise Budgets

The Farm Management Section assembled information on the costs and returns associated with various agricultural activities. Each enterprise budget provides a detailed accounting of the resources necessary to carry out each activity, expected resource cost, as well as expected yield, output price ranges, and net returns. Since very little of this work has been done in Lesotho it was important that the necessary economic benchmarks be established. Such benchmarks are critical for farmers, bankers and other credit managers, government agricultural planners, and policy advisors.

Enterprise budgets for orchards of pear, peach, apple, and apricot orchards as well the semi-perennial crop of asparagus are presented in RD-R-29, and updated in RD-R-60.

Three publications from the Farm Management Section are relevant to irrigation developmant in Lesotho. The most extensive set of crop budgets prepared thus far is for irrigated vegetable crops. These budgets were a central input to a linear programming analysis of optimal enterprise combinations for irrigated farming in Lesotho by Borris (Borris, unpublished M.S. thesis, 1985, Washington State University). The budgets have also been published as a separate Research Division bulletin so that they may reach a wider audience in Lesotho (Borris et al., RD-B-36). Lastly, a bulletin traces the history and development of irrigation projects in Lesotho and suggests improvements for further development (Borris and Holland, RD-B-45).

c. Results From Combination Farmers

As part of the research program coordinated under the Farm Management Section, two farmers in each of the three prototype areas were selected for special attention. The individuals were called "combination farmers" and were chosen because they had the necessary resources of land, oxen, and equipment, as well as the ability and interest to work with personnel from the Research Division. Those practices that combination farmers were asked to try were backed by good agricultural research evidence, and the farmers were expected to pay for the cost of the necessary inputs.

Two research reports describing costs and returns associated with field crops grown by the combination farmers were written. RD-R-37 summarized the results of the 1982/83 season, and RD-R-49 summarized the results of the 1983/84 season. Both of these reports indicate considerable economic success with the package of improved technology tried for field crops. Also discussed are the crop rotations for both summer and winter seasons.

d. Tests of New Agricultural Technology

Pinto beans were introduced into Lesotho, tested extensively in the Nyakosoba prototype area during the 1982/83 growing season, and became the basis for a seed multiplication program in all three prototype areas in all subsequent years of the FSR program. The combination farmers were also introduced to pinto beans. In all cases the response was enthusiastic. RD-R-28 describes the results of the first year of trials with the pinto bean and explains in large part why it has proven to be such a popular crop.

In 1983 the Research Division obtained two small grain threshers manufactured in Egypt. The suitability of these machines was to be evaluated under Lesotho conditions. The results of this evaluation are summarized in Majoro and Holland, RD-B-33. The magnitude of grain saving associated with mechanical grain threshing was surprising.

The results of the on-farm trial program for the 1983/84 summer season are described in RD-B-38. The 1983/84 program was jointly planned and conducted by members of the Farm Management, Agronomy, and Extension Sections. As such it represented a genuine

interdisciplinary team effort. A number of encouraging developments emerged from the trials. The Phase II coulter for the SAFIM planter generally worked very well in the Siloe trials. This coulter, due to its narrow design, should overcome the problems that were experienced with the Phase I and should be thoroughly tested on heavier soils. If it proves effective, arrangements should be made to have Lesotho Steel start making the Phase II improvement.

The row spacing trials in Siloe were interesting because they were the only maize trials to survive in Siloe. Wider rows, in addition to increasing survival probabilities, allow the fertilizer rate per land area to be reduced while maintaining the fertilizer available to each plant at recommended rates. The optimal plant population for maize in the southern lowlands is 18,000-20,000 plants per hectare.

e. Recommendations

It is recommended that at least one farm management economist at the Ph.D. level be maintained at the Research Division until national personnel receive more training and experience.

It is recommended the research personnel for the incomming LAPIS project review the material on irrigated crop budgets for both vegetables and fruit trees (RD-R-60 and RD-B-36). The material in RD-B-36 indicates that most irrigated vegetable crops will not be able to generate an economic surplus under the current configuration of prices and expected yields. A major problem is the current high price of petrol. Before LAPIS goes too far with irrigated vegetable development, some more work will be required to try to design an economically viable system.

It is recommended that all LAPIS personnel involved with setting up irrigation associations review RD-B-46 by Borris and Holland. This publication reviews the history of production associations in Lesotho and makes recommendations for the organization of any future production associations.

It is recommended that RD-B-38, which describes the results of the grain threshing trials, be read and that additional trials be conducted with improved models of the thresher. Mechanical threshing appears to save both grain and labor. The grain saved essentially exceeds the cost of operation of the machine. Assuming development of a suitable prototype model, the manufacture and adoption of such a machine would save labor and grain.

It is recommended that the results of the on-farm trial program that is summarized in RD-B-36 be read. Of particular interest is the performance of the phase II coulter for the SAFIM planter. Further tests should be conducted with this opener in the soils of the mountains and foothills. If they prove satisfactory, a program of local manufacture and extension of this improved technology should be undertaken.

It is recommended that seed stock for Highland White Flint maize and pinto beans be maintained at the Research Division for possible seed multiplication if necessary. Both cultivars represent improved varieties of the respective crops and have the advantage of being open pollinated so seed can be reproduced by farmers.

4. Soils

Soils was not originally included as a major part of the FSRP, but soil management has affected several aspects of the Project, in some cases, rather heavily. This section is divided into three major parts:

- soil development, classification, and survey;
- soil erosion/conservation and survey; and
- soil fertility management.

a. Soil Development, Classification, and Survey

Soil development depends on a combination of five factors: parent material, climate, topography, living organisms, and time. All five factors are involved in the development of the soils of Lesotho.

Classification is a process by which units of a system are placed into categories distinguished by their properties. Soil classification is a science, not unlike the science of the classification of plants or animals. Each unit fits into its place in the classification system. The soil classification system uses these categories: order, suborder, great groups, subgroups, families, and series. This discussion will be concerned only with the order and the series categories. There are 10 orders, five of which occur in Lesotho.

Order	General features	% of Lesotho	No. of series
Entisols	Very young soils with little or no horizon development	4	5
Inceptisols	Young soils, slightly more developed than Entisols	3	2
Mollisols	Soils with dark, usually deep, surface horizon. High in organic matter	43	22
Vertisols	Clayey soils with high shrink/swell potential, cracks during dry periods	1	2
Alfisols	Soils moderate to high in base saturation but highly developed	20	12

A series includes soils of similar profile characteristics except texture of the surface soil. Series names are derived from a town or other geographical site. There are approximately 40 series identified in Lesotho, most of which are Mollisols. This reflects the fact that much of Lesotho is grassland and many of the soils were developed under grassland vegetation.

The soil survey is an applied science in which a surveyor identifies various soils and determines how they fit into the classification system. The only units shown on the soil survey map are those of the soil series and the mapping unit, a subunit of the series. Presumably the soils within a mapping unit are similar enough to require the same management practices. Mapping units within a series are separated largely on the basis of slope and surface texture.

In Lesotho, soil survey work is underway, but progress is slow. Although considerable knowledge about Lesotho soils has been accumulated, the amount of land actually surveyed is small. There are no published survey reports or maps available to the public.

A special mention should be made of Duplex soils in Lesotho. They are unique and have management problems. They are, as a group, the most extensive soils in the western lowlands, and present the most perplexing problems for crop management and erosion control. They are positional in the areas where severe gully erosion has created "dongas".

The upper layer has two or three bleached, highly leached horizons, called the E horizon (formerly A_2 horizon). They are frequently quite acid and low in available P. All truly Duplex soils are Alfisols but all Alfisols are not Duplex soils.

Identification of benchmark soils serves a useful purpose. Benchmark soils are key agricultural soils selected for detailed description, characterization, classification, and interpretation. There are 11 benchmark soils which are described in detail in Section III-D.

b. Soil Erosion/Soil Conservation.

The two topics--erosion and conservation--cannot realistically be separated. An intelligent approach to soil conservation depends on understanding the basics of soil erosion and the factors contributing to it. The very visible dongas (gullies), mostly in the lowland region, are an unpleasant reminder that erosion is a major problem in Lesotho.

Although the dongas are very visible, gully erosion is a small part of the total problem. Although not as dramatic and not even very visible, the preponderance of soil loss is from rill and sheet erosion. At present there are 20,000-30,000 dongas in the lowlands of Lesotho. Most of these are not of recent origin although, no doubt, many of them widen and deepen with time.

Soil conservation has been practiced in Lesotho for approximately 50 years, mainly with contour banks and grass strips. Recently, grassed waterways and diversions have been added, but these are not the complete answer. Contour banks or graded terraces will prevent the formation of dongas but will not stop the sheet and rill erosion between the banks. In soil conservation, three concepts need to be addressed: watershed management, vegetative control, and land use capability.

c. Soil Fertility Management

Generally, Lesotho soils are frequently low in N and more frequently low in P. When both are encountered, P is usually more deficient than N. A few low K soils have been found, but they are rare. Mo and Zn deficiences have been reported but supporting data are rare. Many soils are low in pH and some are very low--as low as 4.0 in some cases. P is believed to be "fixed" in these soils and Al toxicity is a problem. The application of lime increases pH somewhat, and sometimes increases yield.

In a literature survey, out of 80 fertilizer trials, 54 responded to N, 70 responded to P, and 6 responded to K. In Lesotho, most fertilizers are very low analysis and recommendations are expressed, for example:

4 pockets of 2-3-2 (21) per ha

This is explained as follows:

1. A pocket is 50 kg; 4 pockets = 200 kg

2. 2-3-2 is the N:P:K ratio; 21 is the percent total nutrients.

3. A simple calculation reveals the fertilizer is 6-9-6 as percent of N, P, K (not P_2O_5 and K_2O)

4. Therefore at 200 kg/ha the application rate is 12 N, 18 P, and 12 K, on a kg/ha basis.

The system is cumbersome. We recommend it be changed over time:

Year 1. Replace pockets with kg

Year 2. Discard ratio; replace with percent, e.g., discard 2-3-2 (21); replace with 6-9-6 (% N, P, K)

Year 3. Allow for increased use of simple fertilizers, such as treble superphosphate and KCl

Year 4. Allow for sale and use of high analysis fertilizers.

Adjustment will be slow, and will require an educational program, but while the problem is not insurmountable, the solution is predicated on the willingness of the South African fertilizer manufacturers to relabel fertilizer bags.

A reasonably well-equiped lab has been developed and work is being done on soil test methods. Unfortunately a well-equiped lab, even with well-trained personnel, has limitations. For example, fertilizer needs cannot be predicted until soil test correlation research is underway. In such a program, yield-response data from field trials are correlated with soil test data on soil samples taken from the same trials before fertilization. The resulting data provide a basis to predict fertilizer needs and diagnose nutritional problems.

Prior to planting for the 1984/85 season, soil samples from experimental plots in the three prototype areas were analyzed:

Area	pH	Organic matter (%)	P (ppm)	K (ppm)	Total samples
Molumong	6.6-7.5	1.1-8.2	1.4-29.0	25-500	36
Nyakasoba	4.7-6.7	0.4-9.6	0.3-25.0	6-335	44
Siloe	5.0-7.3	0.3-1.0	3.6-80.0	60-162	11

d. Implications

The basic soil survey can contribute to understanding the nature and properites of the soils in an area. There is a national soil classification system based on soil properties, which in turn are based on the way the soils developed. Through the soil survey, each soil is placed in the classification system.

Fortunately, a considerable body of knowledge has been accumulated about the soils of Lesotho. While only a small percent of all cultivated and grazing land has been surveyed, the hectarage is sufficiently large and representative that inferences can be made about most of the agricultural soils in the country, but there is still much that is not known. Anything approaching adequate knowledge of the soils will not occur until all the soils have been surveyed.

Experiences within the FSRP provide practical examples of the need for a complete soil survey. In establishing field trials for work in agronomy, horticulture, or range management, it is important to identify the soil in order to understand plant responses. A published soil survey report with soil maps is invaluable, but is not yet available. In one interesting case, an agronomy trial was planted half on a Mollisol and half on an Alfisol. The crop responded very differently to the two soils.

In only a few instances was the soil series known where trials were located. This knowledge is especially important in the case of fertility trials where fertilizer responses can be related to soil series, and the information used in soil fertility guides.

In summary, there are a number of soil problems in Lesotho, many of them are serious. Examples are erosion, low pH, extreme P deficiency, and physical problems in Duplex soils. These problems cannot be adequately dealt with without a complete soil survey with published reports.

Lesotho's erosion problems have existed for well over 100 years. It is to the credit of the GOL and the MOA that this problem has been addressed beginning in the 1930s. The Conservation Division has made valient efforts. Without those efforts, the problems could very well have been much worse, but to a great extent, the problem remains. It seem obvious that, if agriculture in Lesotho is to survive, increased research, education, and action programs aimed at the erosion/conservation issue are badly needed.

Soil fertility problems have already been mentioned. Many of the constraints to crop production and many of the problems encountered in field trials were related to soils. Agronomists and horticulturists frequently included fertilizer variables in their field trials.

These recommendations are offered:

- There should be a separate Soil and Water Management Section within the RD to address soil fertility, tillage, soil moisture management, general soil management, and irrigation.

- There should be a special effort in research education and action that addresses the entire soil erosion/soil conservation issue. This would be a cooperative effort among Conservation, Research, and Range Divisions. The MOA and GOL would need to recognize the need and devote the necessary resources to the problem.

- There should be a research and extension effort to address the special problems in soil mangement, such as the low pH and P deficiency of certain soils. This problem cannot be resolved with simple on-farm trials. It is a problem requiring basic research, perhaps suitable for a Ph.D. thesis.

- The system for expressing fertilizer recommendations should be changed from pockets of 2-3-2 (21) per ha to kg/ha of 12N-18P-12K

- Develop a soil test correlation research program in order to establish soil test critical ranges. Without this, the soil test lab has very little value to soil fertility programs.

- Allow for a wider variety of fertilizer mixes and for simple fertilizers. When soil test critical ranges are established and recommendations are based on soil tests, this variety will be needed in order for the program to work.

5. Agronomy

a. Crop Production

There are five major field crops in Lesotho (LASA, 1978).

Crop	Area (ha)	1971-76 Avg. yield (kg/ha)	Gross Value ('000 Rand)
Maize	80,400	630	3,644
Sorghum	42,500	690	2,316
Wheat	41,700	580	2,611
Beans	19,600	310	1,766
Peas	9,400	450	973

Crop yields, as reported in 1978, were very low. Grain production had declined from 313,000 t in 1950 to 191,000 t in 1970.

b. Constraints

There are many constraints to crop production:

- Need for land leveling
- Poor seedbed preparation
- Low soil fertility and poor soil fertility management
- Low-yielding varieties
- Inadequate fodder production
- Inadequate draft poqwer
- Poor weed control
- Inefficient or improper cropping systems
- Grain-threshingproblems
- Variable and inadequate plant populations
- Unsuitable or inadequate farm equipment
- Soil erosion
- Cutworms
- Crop unsuited to the area
- Shortage of ox-drawn equipment
- Labor shortage
- Poor condition of oxen
- Lack of inputs
- Poor quality seed
- Plowing in spring instead of autumn

In addition there are uncontrolable factors such as climate (mainly rainfall) and soil properties. Most of the 20 problems were addressed in the field trials.

c. Field Trials

Beginning in 1982, trials were established each year in the three prototype areas, at Maseru, and at six substations. The work involved varieties, soil fertility, weed control, tillage, seedbed preparation, planter comparisons, plant populations, seed multiplication, winter fodder production, and cropping systems. Crops were maize, sorghum, wheat, dry beans, peas, potatoes, and lentils, plus some new crops such as chickpeas, sunflowers, and soybeans.

In 1983-84, 152 trials were planted; in 1984-85, 114 trials; and in 1985-86, 111 trials. Many of the trials were lost before they could be completed, largely because of the many problems and constraints listed above. The results of the 1985-86 field trials will be presented in Volume II of this report, to be published in late 1986.

(1) Maize

Variety Trials. In the lowlands (1982-83), PNR 473, PNR 99, CG 4141, PNR 437, and Sabi 48 performed well, with yields generally 4,000-6,500 kg/ha. During the same year at Nyakosoba, CG 4141 and TX 225 yielded well at about 3,700 kg/ha. At Siloe the same varieties yielded about 3,000 kg/ha. At Molumong, Highland White Flint and American White Flint did reasonably well at 1350 and 1200 kg/ha, respectively.

A special trial was established at Maseru in 1984-85 to determine the potential yield of maize using tractor-drawn equipment and all of the recommended practices. Four hybrids, CG 4141, PNR 95, PNR 493, and TX 14, yielded very well, but the yield of CG 4141 was more than 50% higher than the others at 12,000 kg/ha, 14 times the national average for that year.

CG 4141 appears to have been the most consistently high-yielding variety for the lowlands and possibly the foothills. Several other varieties with good potential are: TX 225, PNR 6427, PNR 95, and PNR 493. For the mountain region, the most promising variety was Highland White Flint.

Soil Fertility. Soil fertility and general responses to fertilizers are described in Section III-D (Soils). Maize yields have generally shown strong yield responses to fertilizer, and, in some cases, have nearly doubled. Responses are primarily to N and P.

Weed Control In 1982-83 chemical weed control trials, Atrazine plus Lasso, Atrazine plus EPTC, and Bladex treatments gave the best results.

Plant Population. Evidently the average farmer plant population of maize is 18,000-20,000 plants/ha. Plant populations ranging from 17,000-48,000 plants/ha have been tried. With normal or higher rainfall the higher plant populations produced higher yields. Under lower rainfall, lower plant populations performed better. Plant populations should be 30,000-40,000 plants/ha, depending on the soil type and the expected rainfall in each area.

(2) Sorghum

Sorghum is a low-risk crop and somewhat more drought-resistant than maize. With adequate moisture, sorghum yields quite well, but not as well as maize. Under conditions of drought stress, sorghum will usually outyield maize. In the southern lowlands, farmers should be growing sorghum rather than maize. Sorghum can also be grown successfully in the foothills and mountain regions.

Varieties. These varieties have done well: Roma White, DC 36, NK 190, and NK 283, PNR 8311, Nyakosoba White, Siloe Best, and PNR 8544. At Linakeng, NK 283 outyielded (5,800 kg/ha) all other varieties tested.

Fertility. The data indicate responses to N and P similar to those on maize. One trial responded strongly to starter fertilizer.

Weed Control. Atrazine, Propachlor, Paraquat, and Propachlor plus Paraquat were effective. Atrazine alone was the most consistently effective.

Plant Population. Two trials at Siloe, one in 1982-83 and one in 1983-84, showed a yield advantage of a 2.0 m row spacing over 1.0 and 1.5 m spacings during the two dry years. The relationship between rainfall, population, and yield exists with sorghum as with maize.

(3) Wheat

Varieties. Prior to FSRP in 1979, the variety which seemed to stand out was Scheepers 69, yielding over 2,000 kg/ha. At Maseru, Machache, and Mafeteng, the leading varieties were SST 103, SWP 2-29, Scheepers 69, and SST 102 with yields of 1,000-2,000 kg/ha. The four leading varieties of spring wheat at Maseru, with yields of 900-1,400 kg/ha were T4, Gouritz, Palal, and Gamka. In a wheat and triticale variety comparison trial, yields between the two crops were comparable at approximately 1,100-1,400 kg/ha. In another winter wheat trial, SST 107 and Scheepers 69 did very well. Scheepers 69 appears to have been the most consistently high-yielding winter wheat of all those tested.

Weed Control. One weed control trial was conducted at Maseru in which there were 20 treatments using seven chemicals alone or in combination. Of the chemicals Glean, 2,4-D, Bromoxynil, Dicamba, MCPA, Faneron, and Basogran, the only effective treatment to control lambsquarters was Bromoxynil plus 2,4-D. A serious problem in wheat, especially in the mountain region, is wild oats. Spring wheat is not recommended in the lowlands because of the Russian aphid problem.

(4) Beans

Varieties. Bean varieties tested which showed promise before FSRP were: White Haricot Late, Michigan Pea, Pink Wacher, Khaki Sugar, and White Haricot Early. In 1983-84 bean trials at Maseru and TY, these varieties yielded quite well at 1,500-2,000 kg/ha: Pinto NW 590, Great Northern 61, Pinto UL 114, Red Mexican 63, Red Mexican 59, Small White Navy (Fleetwood), Great Northern Frontier, and Pinto 410. These recommended varieties are Small White Haricot, Speckled Sugar, Pinto NW 590, Michigan Pea Bean, and Pink Wacher. Small White Haricot is a high-yielding, late-maturing (144 days) bean that has been grown in Lesotho for many years. Pinto yields less but matures earlier (118 days), and was introduced into Lesotho in 1982-83. With the dangers of damage from hail, early frost, and the CMR beetle, the probability of crop failure is reduced when pinto beans are planted. Yields are higher than SWH under these conditions.

Soil Fertility. Two trials, one at Nyakosoba and the other at Siloe, responded well to "starter fertilizer" placed at planting time.

Nutrients rates (kg/ha) of N-P-K were 45-60-45 for Nyakosoba and 28-42-28 at Siloe. Yields were more than doubled with fertilizer, but the yields were low at about 1,100 kg/ha at Nyakosoba and 530 at Siloe.

Weed Control. Chemicals tested were Treflan, EPTC, Basogran, Dual 720E, and Fusilade. The most effective treatments were Treflan and EPTC.

(5) Peas and Lentils

Varieties. Three years of lentil variety trials at Maseru produced mostly low yields, but three varieties yielded relatively well: Precoz, Easton, and Red Chief. At Mokhotlong, Easton outyielded other varieties tested.

Weed Control Out of 19 treatments involving six chemicals, the most effective treatment which left the peas essentially undamaged was Terbutryne alone.

(6) Potatoes

Weed Control. Out of 20 treatments involving six chemicals, highest potato yield and reasonably good weed control were accomplished with paraquat plus Lasso. Other effective treatments were: EPTC, and EPTC plus Lasso.

(7) Minor Crops

Some minor crops are: chickpeas, soybeans, cowpeas, sunflowers, geroundnuts and winter fodder.

Chickpeas Those planted 18 October yielded an average of 1,988 kg/ha while those planted 22 November averaged 462 kg/ha.

Grain and Hairy Vetch, Maseru. Barley-vetch and triticale-vetch were compared with and without fertilizer. Yields did not vary a great deal, ranging from 2,600-3,000 kg/ha, dry weight.

Sunflower varieties, Maseru. Sixteen tested varieties yielded 2,700-3,600 kg/ha. Highest yields were from SO 323, SO 324, AS 504, and SO 215.

Cowpeas--Potential Yield Trial. The average yield was 2,454 kg/ha, which was considered satisfactory.

Volume II of this report will present more information on the minor crops tested for adaptability to Lesotho conditions.

d. Special Topics

(1) Weather Variation

One of the most serious constraints to crop production is the weather variability, especially rainfall. The average rainfall in

much of Lesotho's cropland is probably just sufficient to grow crops successfully, but rainfall distribtuion is usually less than desirable. In nearly 50% of years the yields are below average and in 25% yields are nearly disastrous. The unpredictability of rainfall has a number of important implications, including the decision of whether to raise sorghum or maize, top dressing with N, and plant populations for corn and sorghum.

Sorghum vs. Maize. Sorghum is a low-risk, drought resistent crop compared to maize. Under optimum moisture conditions, maize yields may be double those of sorghum. Under dry conditions sorghum has better potential. Sorghum rather than maize should be grown in the southern Lowlands because of low rainfall and sandy soils.

Side-Dressing with N. The difficult question is how much LAN to apply as a side-dressing to maize or sorghum, when it is impossible to predict if there will be sufficient rainfall to increase the yield from the additional N. In wet years side-dressed LAN will have high payoff, in dry years the investment may be wasted.

Plant Population. Optimal plant populations for maize and sorghum are related to rainfall variability in much the same way as the previous two examples. Plant population studies indicate that for maize, 30,000-40,000, and for sorghum 40,000-50,000 plants/ha are optimal. Under dry conditions, populations should not exceed the low figures.

(2) Autumn Plowing

The advantages of early autumn plowing are:

- More effective use of the limited number of oxen. The oxen are stronger from eating green feed.
- Moisture conservation. Plowing allows better infiltration of the limited winter rainfall.
- Control of cutworm. The reasons for this are not well understood, but the effect is fairly well established.
- Early decomposition of incorporated organic material provides better tilth and early nutrient release from the crop residues plowed under.
- Better control of early weeds.
- Fields can be planted earlier in the spring.

(3) Principles of Weed Control

Of all the problems and constraints to crop production, weeds rank among the most serious in Lesotho. Two maize trials clearly demonstrate the problem:

Treatment	Yield (kg/ha) 1	2	3	4	5
No weed control	190	200	155	0	474
Weed control	2,466	2,750	2,517	2,387	3,071

Treatment	Maize yield (kg/ha)
No control	200
1 hoeing, 2 weeks after planting	1,600
complete control, 1st 4 weeks	1,591
complete control, 1st 8 weeks	2,450
complete control, all season	2,750

Of course, weeds can be controlled by tillage and hand hoeing, by chemicals, or by a combination. Probably the general use of herbicides will not be appropriate for a few years, but in planning for future programs, this approach should not be discarded. In any case, the importance of the weed problem in Lesotho does not seem to be fully appreciated.

(4) Cropping Systems

Different cropping systems each have their own purpose.

- Crop rotation--to control pests and spread the risk.
- Double cropping--cropping in winter and summer for more efficient use of a given field.
- Green manure crop--a crop grown to be plowed under mostly to improve or maintain desirable physical and chemical properites of the soil. Such a crop may also have been used for another purpose such as grazing.
- Winter feed--winter fodder, especially for oxen, is a critical need.
- Crops for food or cash--maize and sorghum are very important in the human diet in Lesotho. This subject is discussed in some detail in Section III-E.

(5) Soil Fertility Management

Yield responses to fertilizer are very common in Lesotho, especially to N and P. N responses are more frequent, and the responses are usually greater than from P alone. When recommended amounts of N and P were applied on a farmer's field in the Nyakosoba prototype area, approximately 8,000 kg/ha of maize was harvested. K, Zn, and Mo deficiencies have been reported, but the extent of these has not been clearly established.

At present fertilizer recommendations are based on the available fertilizer response data. With a soils lab in operation, there is a potential to make recommendations on the basis of soil tests, but this cannot happen until the soil tests are evaluated in soil test correlation research using fertilizer field trials. Crop responses could then be correlated with the soil test values. This is now being done on a limited scale, but a much more comprehensive program is needed.

e. Implications

One goal of the FSRP is to improve the quality of rural life. The agronomic implications of this goal are increased crop yields, total crop production, and exports, leading to an improvement in the country's balance of payments. During the 7 years of the Project the data documenting such increases are limited, however, the following points are useful:

- The 20 constraints listed earlier were addressed in the on-station and on-farm trials with farmers, and in Extension programs.
- By using improved varieties, fertility management, weed control, and optimal plant populations, high yields of maize, sorghum, wheat, and beans were obtained on-station and on farmers' fields in the prototype areas.
- In most cases these served as effective demonstrations to field Extension workers and leading farmers of management required for high production.
- Field observations show that more farmers are applying fertilizer and planting improved varieties today than in 1979 prior to the Project.
- Probably the best evidence of progress is found in Section III-J (Extension) where, in terms of knowledge, attitude, skills and aspirations, the data show positive changes.

There is good reason to believe the Project has set in motion an improved technology that will reflect, in perhaps another 7 years, a significant improvement in crop production and in the quality of rural life. However, this optimistic projection will not occur solely on the basis of what happened during the Project. It is essential that the momentum continue. The cycle of the Farming Systems approach cannot stop or slow down, research agronomists and extension personnel must continue to work with farmers on solutions to crop production problems. This will not happen without the support of GOL and the cooperation of MOA.

6. Horticulture

Most of the work on horticulture was done under the leadership of Dr. John Downes during 1984-86, although a limited amount of

observational work was done by Dr. Clark Bllard during 1981-83. Data from 1985-86 will be published in Volume II of this report, which will be available in late 1986.

In 1979 when the FSR Project began, the total hectarage for hoticultural crops (4,800 ha) in Lesotho was very small compared to that for field crops (1,105,000 ha) (LASA, 1978). Nearly all the 4,800 ha were in peaches, leaving very little land for all other horticultural crops. It is of interest that the estimated annual value of peaches was greater than any other crop, including maize or sorghum. Most of the peaches were grown in backyard plantings.

It is doubtful this situation has changed appreciably. Some crop production and value data are shown in Table 1.

Table 1. Horticulture production and value data, Lesotho, 1978

Fruit crops	Trees ('000)	Yield (kg/ha)	Farm Price (R/kg)	Gross value (R)
Peaches	1,000	9	.45	R4,050,000
Apricots	60	7	.42	176,400
Apples & others	45	8	.40	144,000
Sub total	1,105			R4,370,400
Potatoes	90	12,000	.12	129,600
Cabbage	40	10,000	.35	140,000
Asparagus	90	800	.20	14,400
Home gardens	130 plots	---- R15/plot ---		1,950,000
Sub total	220+			R2,233,000

Source: LASA, 1978.

The data clearly show the contribution to the national income of these crops, aside from peaches, is small, but vegetables for home consumption are considerable, with a value of nearly R2 million or about 11% of the annual gross income. About 90% of rural families in Lesotho raise garden vegetables.

Enterprise budget studies have been made for irrigated vegetables (Borris, 1985, RD-B-36) and supplementally irrigated tree fruits (Carvalho, 1983, RD-R-29). Fruits which appeared to show considerable promise were apples, peaches, and pears. Vegetables on the average were not quite as promising, and showed somewhat less net return to family resources. Vegetables studied were potatoes, cabbage, onions, tomatoes, carrots, and beetroot.

In a separate study (Carvalho, 1983, RD-R-29), asparagus had considerable promise. An asparagus cannery, constructed near Mazenod,

has operated quite successfully in cooperation with up to 100 or more growers. Other crops being considered for processing at the same plant are peaches and dry beans.

In summary, irrigated vegetables, supplementally irrigated tree fruits, and non-irrigated asparagus all appear to have potential for commercial production in Lesotho, although tree fruits and asparagus show considerably more promise than annual vegetables. The crops being considered were:

Tree fruits	Vegetables	
Apples	Potatoes	Carrots
Pears	Cabbage	Beetroot
Peaches	Onions	Pumpkins
Apricots	Tomatoes	

Nearly all the horticultural experiments under the FSR Project were with vegetables. In soil fertility, considerable work, both within and outside the Project, repeatedly indicated the nearly universal need for N and P for vegetables, especially potatoes. The need for P is more frequent and usually greater than the need for N.

Tree fruits (apples, pears, peaches, plums) were planted in all three prototype areas in 1984-85. The 60-70% of the trees which survived are doing quite well. Lack of water is a serious problem. Fruit plantings at Maseru are also doing well, but additional plantings are needed, especially in areas with better air drainage.

Potatoes responded consistently at Nyakosoba to increasing rates of 2-3-2 (22) + Zn, up to 1,200 kg/ha fertilizer applied. In terms of kg/ha of nutrient, this is equivalent to 72 of N, 108 of P, and 72 of K. The rate of P_2O_5 is of interest--245 kg/ha compared to 72 of N. At Molumong, whole seed yielded more than cut seed, and seed treatment with Thiulin fungicide yielded more than untreated seed. At Siloe, yield responses to irrigation and ripping to 60 cm in a Duplex soil were obtained. Data indicate in-row spacing of 80-100 cm may be preferable to closer spacing. This will save on seed cost, a rather high cost item.

Vegetable research for the 1984-86 period was mainly concerned with cabbage, potatoes, tomatoes, onions, and beetroot. Trials were conducted in cooperation with farmers and community gardeners in all three protytype areas. A reasonable evaluation of the more promising cabbage hybrids was obtained. Unfortunately, the open-pollinated cabbage varieties involving much cheaper seed were seldom included. Data indicate rates of fertilizer higher than those recommended would be profitable under irrigation and good management. A plant spacing of 45 x 45 cm appears to be optimum for cabbage. Promising hybrids are: Pak cha, Tokyo Pride, Bonanza, Hercules, Shamrock, Roton, and Green Star.

Intermediate and short-day onion varieties such as Texas Early, Granex 33, Pyramid, and Hojem seem well-adapted to Lesotho. The best time of planting appears to be mid-August.

Intercropping tomatoes in maize may be successful with adequate moisture, but may fail in dry years. Trellising of tomatoes appears to be essential for high yield and quality. Leading varieties appear to be Valox, Piersol, Heinz 1370, and Floradade.

For pumpkins, Flat White Boer and Queensland Blue appear to do well.

Much research remains to be done to improve the basis for establishing a really viable domestic vegetable industry in Lesotho, and the infrastructure for transport, distribution, marketing, and storage must be improved. This research should include an economic evalution of input levels and practices as well as cultivars. Well-trained personnel are needed. A well-trained applied statistician is also needed in the Research Division. Development of water for irrigation and domestic use in rural areas is of prime importance to any expansion of vegetable production.

7. Animal Science

a. Trials

The cattle feeding trials demonstrated that cattle could be finished on simple rations available to farmers in Lesotho. Fattening mature oxen was quite inefficient and required three times the feed per kilogram of gain as for young animals 1-2 years old.

Klosterman introduced the idea of feeding concentrates to oxen during the winter months to improve their strength and ability to work. Prototype area farmers are aware of the advantages, and several practice it to the extent conditions permit. The concept of supplying supplemental feeds to livestock has been enthusiastically accepted by farmers in the three prototype areas and the Bushman's Nek Woolgrower's Association, who cooperated in a trial with sheep and goats. Interest in improving the condition of animals through better nutrition is indicated by farmers' willingness to spend money to grow fodder crops and to purchase hominy chop, Rumevite, or other concentrates. The formation of a fodder association with over 60 members in the Siloe prototype area and the subsequent planting of 20 ha to fodder crops is indicative of their growing interest. It is especially of interest to farmers in the lowlands where pasture is scarce and there is limited opportunity to move them to better feed.

The performance of sheep and goats kept on mountain ranges all year was improved considerably by supplementing their diets with both protein and energy sources. The reproductive rate was increased to nearly double the national average in sheep and by approximately 20% in goats. Wool production was significantly increased with better nutrition.

The pilot poultry trial conducted during the 1985/86 season indicated that farmers could successfully produce eggs from hens kept in simple housing. If properly fed and protected against diseases, egg production from the Isobrown breed was nearly 90%. Egg production from this improved breed was clearly superior to the mixed-breed, native birds. At prevailing prices there was a positive return over costs if the chickens were properly managed. The cooperating farmers were very interested in keeping hens, and all but one of the eight farmers continued with egg production after the trial was terminated. Obtaining feed that would support a high laying rate was the single most serious problem the small flock owners faced. Transporting commercial laying mash to their farms was impossible for several of the cooperating farmers.

b. Implications for Future Programs

The improvement of the animal industries is complicated by the complex interrelationships that exist among livestock owners, consumers, traditional patterns of land use, cultural practices associated with animal use, government agencies, marketing systems, and the influence from South Africa. One aspect of the livestock industry in Lesotho that confuses the issue of "increased production" is the multiple reasons for which animals are kept. To be successful, a program to help livestock owners cannot increase one desired use of the animal(s) at the expense of another that is just as desirable in the eyes of the owner. In the case of cattle, meat production is probably not the highest priority in the minds of most Basotho farmers. Draft power is an important consideration, the sale of milk and dung is common, and replacement animals may be difficult or expensive to obtain.

The use of communal range and the lack of other investment opportunities encourage farmers to keep a maximum number of animals, even though the production per animal may suffer. Farmers are interested in increasing production of milk, meat, and wool, but as Klosterman (RD-B-13) noted, several projects that demonstrated this in a positive manner had little influence in changing the management patterns of Basotho stockmen. What is technologically and/or biologically required to increase the production of a particular animal product is largely known, but how to encourage livestock owners to do so and the economic feasiblity of such change are missing elements.

Several events will need to occur to bring about a major change. These include: improved marketing opportunities, developing an alternate source of draft power to eliminate or reduce the dependence on oxen, finding winter feeds that are economically sound for the situation in Lesotho, better management of the rangelands and pastures of the country, and government programs that provide incentives for the production of desired animal products. There are indications that some developments are occurring that will influence animal production even though they are relatively insignificant at the present time. The increasing farmer interest in growing animal feed to supply their

animals with better quality supplements, the formation of several herd improvement associations, and the recognition among villagers that something must be done about the condition of their animals (even though they often don't know what or how), are all indications that with educational programs and encouragement, changes will occur.

Research into the economics of fodder production and of feeding concentrates is needed to determine the long-term feasiblity of such a practice under Lesotho conditions. Likewise, research into marketing systems and their influence on the management practices of livestock owners is needed to compliment production studies. Continued research into the attitudes, desires, constraints, management practices, and capabilities of livestock owners is needed to assess the potential acceptance of proposed programs.

Lack of sufficient feed during the winter is the most serious nutritional problem facing livestock owners. A closely associated problem is the low protein content of winter feeds that are available. The energy from feeds such as dry grasses and crop residues, especially maize and sorghum stover, is poorly utilized if the diet is protein deficient. The nutritional deficiency is therefore compounded, and the farmer faces the need to supply both additional energy and a source of protein. How to supply needed nutrients during winter is a key to making significant changes in the management and productivity of Lesotho's herds and flocks. Using oats, barley, or wheat for winter pastures can help overcome these deficiencies, as can feeding legume hay. The finding by the Range Section that certain introduced grasses retain a high protein content during the dry, cold Lesotho winters has important implications that should be explored.

The make-up of the national livestock herds over the last two decades does not provide much hope to alter the situation in the near future. Since 1974/75 the total number of animal units in Lesotho has averaged 1,117,500 with the 1985 numbers 70,000 less than in 1970. When cattle numbers rose during the late 1970s, sheep and goat numbers dropped. Cattle numbers have been decreasing since 1979 and small stock numbers have increased. The very attractive price of mohair, and to a lesser extent the price of wool, has provided an economic incentive in recent years to increase the number of sheep and goats.

Since cattle imports were restricted in 1980, the national herd has decreased because of the low reproductive rate. Lesotho has historically depended on feeds from South Africa, and is at an economic disadvantage when competing with producers from the RSA. The restriction on egg imports has allowed a layer industry to develop and thrive in the country, while fryers are produced more economically in South Africa, and most are imported. The recent increases in the cost of poultry feeds, and the announced increases to occur in the next few months, has created a a serious problem for Lesotho's egg industry.

Livestock owners in Lesotho wish to improve the condition of their animals and apparently respond to economic considerations, but

major changes in the animal industries are unlikely to occur unless several influencing factors and situations also undergo change. These include:

- the development of alternative sources of draft power to reduce the dependence on oxen for farming operations;
- the development of roads and transportation systems throughout the country that will allow inputs and animal products to move efficiently and economically;
- the construction of storage facilities so the quality of animal products can be maintained;
- a functioning, economically-sound marketing system that recognizes and rewards the producer for quality;
- a fair and enforceable method to regulate grazing animals according to feed supplies, and;
- the institution of a continuing educational program for farmers in all aspects of animal production.

Some of the influencing factors are outside the usual scope of an agricultural development project, but previous experiences have had little success in promoting meaningful change in Lesotho by concentrating on aspects of animal production *per se*. A system to supply the needed feeds for the animal industries in Lesotho at economically feasible prices would probably have the greatest impact. The potential of Lesotho's large animal industry to contribute substantially more to the nation's income than it now does makes an integrated effort by government and donors a worthwhile endeavor.

8. Range Management

Lesotho's rangelands are overgrazed. For many years, the total livestock numbers have been approximately double the estimated total carrying capacity of Lesotho's rangelands.

Range vegetation does not recover quickly. Research has shown that, even where there is an early increase in vigor of some species, there is no permanent recovery within one or two years following protection. The recovery rate depends on the condition of the vegetation, soil properties, available seed of desirable species, and rainfall. These factors are currently being evaluated in terms of "leboella", or resting the range. Until livestock numbers are balanced with carrying capacity, there is little point in correcting other factors. It has been demonstrated repeatedly that such practices as range reseeding, brush control, and introduction of new species are not effective on range that remains overgrazed.

In no sense does this imply that research should not continue. It is hoped that animal numbers will be brought into balance with carrying capacity by thoughtful planning rather than by nature through catastrophic events such as droughts.

FSRP Range Management research programs were conducted under the leadership of James A. Tiedeman in 1979-83, and Carl. J. Goebel in 1983-86. A number of others who made significant contributions are listed in Section III-A (Administration).

Section III-G is divided into eight subsections.

a. Range Conditions and Range Resting

(1) Range Condition and Trend Monitoring in Molumong

Forty permanently marked transects were sampled for species frequency and basal cover in 1981 and 1982. Readings were significantly different from one year to the next, but differences were small and the degree of utilization affected parameter readings. These results demonstrate that the trend in range condition in Molumong can be monitored from these transects but should be compared over long periods (5-10 years). Although not significant, it appears that the total vegetation basal cover is decreasing in the Molumong prototype area.

(2) Rested Range Exclosures

The vigor of the dominant grass species improves after one year's rest, but forage production and vegetation basal cover requires more than one year's rest to improve. Contrary to popular belief in Lesotho, range condition cannot be improved rapidly with one year's rest nor does forage production increase substantially. Lesotho's rangelands require many years of either rest or deferred grazing under proper stocking before substantial improvements can be expected.

It was concluded that light grazing pressure would provide better protection of the soil from erosion than no grazing, and most certainly better protection than heavy grazing. Proper stocking rates and deferred grazing rotations would be a better alternative for range improvement than complete rest followed by heavy stocking once the area is reopened to grazing under the communal system.

b. Stocking Rate

(1) Proper Stocking and Supplemental Feeding of Sheep and Goats

Nine farmers each contributed 20 ewes and 20 angora does for the trial. The treatments were light stocking and heavy stocking on communal range, each with and without protein-mineral supplemental feeding. After the first year average wool yield and quality per sheep, ewe liveweight, and lamb crop were highest for the lightly-stocked/supplement treatment, followed by lightly stocked/no supplement, and lowest for the heavily-stocked, communally grazed/no supplement.

c. Range Burning

The impact of uncontrolled burning of range during winter was evaluated for three sites in Nyakasoba 3 years after the burn. Forage production and grass species vigor were measured on the four treatments of burned or not burned, and grazed or not grazed. No differences were detected for species vigor between burned and not burned, but vigor was much lower (significant at P = 0.05) on grazed range (7 cm leaf length) than on not-grazed range (17 cm leaf length). Over a 3 year-period, forage production was reduced by 25% from burning (significant at P = 0.05) for the drought year of 1983.

d. Rotation Grazing and Seasonal Harvest

(1) Short-Duration Rotational Grazing System Trial

A nine-pasture rotational grazing system was successfully established without fence for the entire grazing area of the village of Ha Mokela in the Nyakasoba prototype area. Pastures were consistently rotated with each receiving 1 week of grazing followed by 8 weeks of deferment. This trial demonstrated after 3 years that farmers are willing and able to cooperatively rotate pastures. The proper stocking rate has not yet been achieved, but the stocking rate was reduced after farmers cooperatively sent their livestock to the summer cattle post earlier than previous years.

(2) Seasonal Harvest of Standing Crop Vegetation From Various Vegetation Types in Lesotho

The effect of seasonal harvesting on plant vigor, vegetative cover, reproductive culm density, and total standing crop biomass was evaluated on four mountain sites in Lesotho. Most plots were harvested once annually for a particular month, and reharvested during the same month over 4 years to simulate seasonal grazing. All plots were evaluated in the autumn of the fifth and sixth year.

The vigor of Themeda triandra, as estimated by leaf length, was significantly greater on the spring-harvested and control plots than on the summer harvested plots. The vigor of Hyparrhenia hirta was greater on plots that received one year's rest after autumn harvest than plots harvested annually in the spring. It appears that early spring grazing with summer deferment is less detrimental to Themeda triandra range than summer grazing.

e. N Fertilization

Nitrogen Fertilizer Rates and Harvest Frequency Response from Two Varieties of Erogrostis curvula.

Ermelo and American Leafy varieties were grown during 1975-80 at Matelile in the Mafeteng District. Five N treatments ranging from 0-90.5 kg/ha were applied as LAN. The plots were harvested at 3, 8, 10, and 12 weeks. In every case, there was a response to N for each of the 5 years, for both varieties and for all three harvest intervals. There was a strong trend toward higher yields with longer harvest intervals.

f. Brush Control

Handpulling and burning were most effective in reducing shrub density in comparison to the grazed control.

g. Nutritive Value of Forage.

(1) Seasonal Changes in Nutritive Value of Rangeland Vegetation

The quality of forage from Lesotho rangeland varies from one season to the next and from one vegetation type or plant species to another.

Rotational grazing systems and supplemental feeding programs could be devised to take full advantage of the seasonal fluctuations in the nutritional quality of range vegetation. For instance, range vegetation high in protein during winter seasons would be best reserved for winter grazing. The seasonal quality of the range vegetation in Lesotho has been assessed to make recommendations for grazing systems and supplemental feeding that could increase the production of Lesotho's 1 million animal units.

Crude protein values were below the minimum levels required for sheep and cattle during winter and early spring in the low mountain zone of Lesotho. Invitro digestible dry matter was also low (below 45%) from June-October in the low mountain zone.

(2) Protein Values of Grasses Adapted to Lesotho

Little information has been available on nutritive quality of the important forage species adapted to the country. If some species are more nutritious than others, then rotation programs could be planned to utilize particular vegetative sites when their nutritive values are high, and avoid sites with low nutritive productivity, or supplement the grazing animals.

There was also a need for information on the nutritional quality of introduced grasses. Again, the critical period of winter grazing is when such grasses may be of the greatest value for Lesotho's rangelands. Data analysis showed that there were no significant differences between the nutritive values of the native grasses of the mountainous sites. Crude protein content (2-3%) was below the minimum level required for cattle and sheep in native species during winter months (Table III-G-14).

All native species averaged slightly higher in crude protein in the spring months of September and October than during the summer. These slight differences were not significant.

Except for Harpecholoa falx, there was no dramatic decrease in crude protein values from the summer to the fall. Thermeda triandra appeared to maintain its nutritive value at a higher level than the other native grasses, except during the winter months. Merxmullera disticha averaged lowest in crude protein values for the entire grazing year.

At the lowland site of Thaba Bosiu, the abundant Hyparrhenia hirta illustrated a different pattern (Table III-G-15). Although this native species also indicated an overall low nutritive value through most of the grazing periods, its highest crude protein value was during the summer months rather than the spring. However, only one sample was analyzed for each of the four grazing periods.

Crude protein and production values for introduced grasses established at Maseru exhibited variable results. Lolium perenne leaves showed the highest crude protein range from 13.2-16.6%, and averaged 15.3%. Stems were lower, and ranged from 9.6-10.2% averaging 9.8%.

Festuca arundinacea stems and leaves illustrated the variability of such a mixture. Crude protein values varied from 3.9-8.0% with an average of 5.6%. Even these relatively low values were much higher than the native species collected at Thaba Bosiu or those collected at Mokhotlong during the winter months. They were 200-300% higher, while the L. perenne leaves were 800% higher than the native species.

h. Ten Years of Reseeding Trials in Lesotho

Range reseeding trials were conducted over a 10-year period at four locations: Maseru, Molumong, Libibing, and Nyakosoba. The trials were observed and evaluated during 1980-85 and classified as "most successful", "less successful" and "unsuccessful" (Table III-G-15).

i. Discussion

The current low production level of Lesotho's rangelands has been caused by reduction of the carrying capacity since the drought of 1933 and subsequent periodic wet and dry year cycles. Animal population was greater than 1 million animal units before 1933. Since it dropped following that dry spell it has never reached that level again. Rangelands have been grazed continuously without a rotational system that could ensure vigor and regenerative capacity of range species. Adjustments of animal numbers have not been made during dry periods.

Some emphasis may be put on the following:

- The Range Division should prepare detailed grazing management plans based on the available climate, soils, and vegetation inventory data. These plans should be made in a team effort for each district. Preparation stages should start with collection of necessary data by a district range officer and other support staff. It would then require joint preparation of a grazing plan with a range management officer from the division headquarters. Consultation and approval of the District Agricultural Officer should be sought before any plan can be sent to the chiefs and authorities in any particular area. The district range officer should then discuss the plan for that area with the local authorities and livestock owners.

- Good plans require as detailed information on vegetation as possible. Classification and mapping of vegetation should be done on an on-going basis.

- Along with a grazing plan, range condition trend studies should be made in order to monitor changes. A quick-frequency method may be used together with a photographic record. It is not necessary to do this on a yearly basis.

- Formation of grazing associations should be continued.

- In order to overcome livestock distribution problems, associations should then be encouraged to purchase mineral blocks. Water developments should be made by associations with some assistance from the government.

- A grazing fee should be introduced. In that way, some of the funds can be used for range development, such as water and reseeding.

- Nutritive value of range forage species should be ascertained. Animal performance and production efficiency require knowledge of energy, protein, phosphorus, and calcium requirements so that adequate supplementation can be made when necessary. Under the auspices of Southern African Regional Commission for Conservation and Utilization of the Soil (SARCCUS), arrangements may be made so that samples of forage species can be analyzed by a member-country which has the facilities and equipment.

The problems of overstocking and low productivity associated with communal grazing in Lesotho have been recognized for many years. That livestock numbers need to be reduced is universally accepted, but there is one overwhelming constraint to an acceptable solution: with a desire for livestock ownership and a share in the free range resource, who will reduce numbers of what animals and to whose benefit? Any animals by one individual will be replaced by someone else.

If, in fact, money can be substituted for, or used to buy livestock when needed to meet Basotho social obligations, the basic cause of overgrazing appears to be more economic than social. Financial returns from cattle, in addition to cash when needed, include draft power, fuel or fertilizer, milk, and meat. With a potential for cash return, investment in cattle may be much more rational than generally acknowledged. The underlying economic problem is that, with essentially no production costs, people can and must own livestock if they wish a share in the national range resource.

If the postulation that current economic opportunity exists is true, it would seem possible to start Lesotho on the way to a more productive livestock industry without a sudden reduction in livestock numbers. Reduction in numbers could become voluntary if production costs were increased for the minority of people who own the majority of the livestock, and it were possible to obtain a share in the range resource without the necessity of owning livestock.

Grazing permits have also been suggested and would seem to be a more feasible approach. Basotho are familiar with permits now in existance. However, these permits are available without cost, and although issued fairly, there is undoubtedly a feeling among people from other districts that partiality is being shown. Thus, they have been nearly impossible to enforce.

Grazing permits imply an economic value for range. A system of distributing lease permits in some equitable manner could provide rental income to those without livestock. However, this would limit the number of permits to establish some not fully agreed upon stocking rate. Thus, the problems of how to equitably distribute how many permits and at what cost would still remain.

j. Summary

It would appear that Basotho are increasingly able to use money to replace or buy livestock to satisfy social obligations, that costs of production have been too low to have forced development of a productive livestock grazing industry, and that the opportunity still exists for a progressive stockman to obtain a return on his investment. If so, reduction of livestock numbers could become voluntary through a system of marketable grazing permits which would distribute range benefits equitably, be a source of income for the non-livestock owner, and require the larger owner to commercialize his operation.

Traditional range-use practices were at one time efficient when livestock numbers were not excessive. These traditional practices are no longer effective today since the total number of livestock in Lesotho far exceeds the capacity of the rangeland. The fact that Lesotho's rangeland is overstocked is well documented in the literature, and is recognized by range and animal science professionals and even casual observers, but most especially by the livestock farmers themselves. The farmers may not interpret the problem as too many animals, but they understand it as "not enough grass". This problem could only be solved by feeding extra forage or by reducing livestock numbers. The present range feed supply is only sufficient for livestock maintenance, plus a small amount of production, if any at all.

k. Recommendations

- Range research should concentrate on solving the critical problems of overstocked communal range. Emphasis should be on range managed cooperatively by groups, but also alternative permit systems, tests of new or propsed regulations, and evaluation of enforcement alternatives to livestock control.

- Low priority should be given to research on improvements such as range seeding, brush control, or fertilization. Such improvements followed by excessive overgrazing would cause more damage than good. Some intensive research improvements should continue, but be geared toward demonstration plots.

- Greater emphasis should be placed on research of village grazing systems, particularly selective leboella. A complete understanding of the permit system is essential, followed by modifications to be evaluated with emphasis on stock control. The "holistic" management scheme should at least be considered.

- The interdependency of the livestock/range component of the farmers' system has been seriously neglected. Enterprise budgets that compare potential livestock income as one of the alternatives to potential income from various crops need to be investigated.

- Greater emphasis needs to be given to the study of farmers' resources at the village level. Are critical resources deficient at the village level? If not, how are they mobilized, shared, etc.? This is particularly important for the livestock/range sector since village range resources are shared and managed at the village level.

- At least a few combination farmers and on-farm trial cooperators should be selected from farmers already cooperating in range/livestock trials (such as members of the Lebamong milkcow association). Farmers who have access through an association to properly stocked range may benefit by growing forage in rotation with their food crops, but it may not be economical without access to properly stocked range.

- Greater emphasis needs to be placed on increased meat production from both sheep and goats, in addition to the present emphasis on increased wool quality and quantity.

- Livestock breeding programs need to be integrated with range management. An animal with good genes does no better on overgrazed range than an animal with poor genes.

- Perennial forage grasses and legumes should be grown by farmers who own abandoned fields, or by farmers with a shortage of the labor or resources needed to properly plow and manage all their land. This is particularly important in the Siloe area.

- It does little good to research perennial forage varieties when nearly no farmer presently grows either of the two proven perennials (lucerne and weeping lovegrass). Research on why these are not grown and how to incorporate them into the present system (if desirable) is more important than variety trials.

- One-third of the families in Lesotho have nutritional disorders with diets too high in energy, but too low in protein (Anderson, 1978). Research should emphasize increased production and marketing of animal products (mutton, milk) consumed at the local level rather than at the national export level. The Project objective is to increase the quality of life of the rural poor, not necessarily to increase national revenues through speciality export crops.

- The first step to range management is usually to map and inventory the range resource, and then determine recommended stocking rates. This is not the most efficient approach in Lesotho where nearly all rangeland is over-stocked and range conditions are deteriorating. The first steps might be to document traditional practices, map traditional grazing areas, determine present stocking rate of the areas, recommend reduced stocking rates, and monitor range condition trends. If range conditions do not improve or stabilize, stocking rates should be reduced further, and measures taken to assure proper livestock distribution.

1. Implications

The data generated by the Range Management Section during 7 years of the Project, while not massive, make a significant contribution to the knowledge of grazing and grazing lands in general, and in Lesotho. More specifically, much of the effort was directed toward the overgrazing problem.

The basic rangeland problem in Lesotho is overgrazing, and the potential solutions to the problem are economic, social, and political, not to be found by conducting field trials. It may also be assumed that through educational programs, application of improved range management methods not only will have little or no beneficial effect on overgrazed land, but it may actually do more harm than good.

However, this is not an argument to discontinue or reduce long-term research efforts. To suggest that range research should be discontinued until livestock numbers are reduced, is short-sighted thinking. Priority should be given to resolution of the social, economic, and political aspects of the overgrazing problem. Research, especially, long-term trials, should be continued in the areas currently receiving attention.

9. Marketing

The marketing economists were asked to analyze the agricultural marketing systems and marketing policies; and to describe the systems of inputs, crops, livestock, and livestock products. During the Project there were three marketing specialists: Emer E. Broadbent, July 1979 to January 1980; Peter W. Wyeth, August 1980 to March 1984; and Ray F. Brokken, July 1984 to June 1986.

a. July 1979 to January 1980 (Broadbent)

Broadbent's tour was cut short by a sudden serious illness. He reported on an extensive field trip to study wool and mohair marketing, including:

- Compilation of 1978/79 wool and mohair pricing and volume data by distrct, and information on programs and policies to improve the wool and mohair industry;

- Interviewed management of marketing bodies (Farmer Cooperative Brokers, South African Wool and Mohair Boards) about product improvement programs for wool and mohair;

- Obtained and evaluated confidential data to assist in developing marketing programs in Lesotho; and

- Studied the Transkei system for marketing wool and mohair as a model to improve the Lesotho system.

Broadbent recommended a duplication of Transkei system, which seemed to work quite efficiently. The report was useful for further development in wool and mohair marketing.

b. August 1980 to March 1984 (Wyeth)

Wyeth wrote or coauthored eight research publications and three extension circulars. In addition, he presented several extension lectures, supervised a thesis on credit use in one prototype area, developed several short reports, and was heavily involved in collecting and analyzing the Baseline Survey data.

(1) Bibliography on Agricultural Marketing (RD-B-4)

This annotated bibliography covered the marketing literature, most of which analyzed government marketing agencies rather than farm level marketing.

(2) Input Marketing (RD-B-5, RD-R-4)

Two input marketing projects were undertaken. The first dealt with seasonal input distribution under Coop Lesotho.

In 1981, Coop Lesotho took over a selected number of stores from the Produce Marketing Corporation (PMC), which was abolished by Parliament that year. There was some debate about the adequacy of input distribution, the number of stores that should be kept up, and the pricing of inputs, especially fertilizer.

The purpose of this paper was to make suggestions about pricing (which were adopted, although not necessarily because of this paper), and about how input distribution might be extended beyond Coop Lesotho's stores. The latter involve truck deliveries of inputs by Coop Lesotho to remote areas beyond it's stores, and a role for private traders. At the time Wyeth believed control of private traders' prices might be feasible under certain circumstances, but he became less optimistic, and emphasized instead that Coop Lesotho should compete with private traders to inhibit charging extortionist prices.

The second project dealt with input and crop marketing for Block I, (the Leribe/Buthe Butha region of Lesotho), in cooperation with the Basic Agricultural Services Project (BASP).

A very large survey was conducted by BASP. Part of it was about the purchase of inputs and the sale of crops by farmers. Wyeth analyzed the data about markets at the farm level. The main finding about crop sales was that there were very few of them. According to the farmers, this was due to low production rather than any problems making sales or obtaining adequate prices. When considering the purchase of inputs, farmers were most concerned about lack of money and access. Recommendations to provide credit and better access follow from these findings, but the paper warns that both problems may be due to a perception by farmers that the cost of buying and transporting inputs are high relative to the benefits they can expect from increased yields. If so, and they are correct, they should not be buying any more inputs than they do because the benefits are low. But if they are incorrect, and the true benefits are high, then better information from research through extension about the benefits is the remedy.

(3) Impact of Marketing on Production (RD-B-26)

This was a cooperative project of the Marketing Section of the Research Division and the Planning Division that was requested by the Minister of Agriculture to examine the production trends in food grains and, if downward tendencies were discovered, to determine whether they were attributable to marketing difficulties of any kind. Areas planted to crops were examined as an indication of production trends intended by farmers. Considerable year-to-year variations were found, with possible downward trends in peas, beans, and wheat. Explanations other than marketing difficulties were considered, including the rapid growth in mine ages, which was thought to have reduced the incentive to produce crops.

Under the heading of marketing difficulties, inappropriate producer prices and an inadequate number of sales outlets might have had some depressing effect on intended production, especially peas and beans, because larger proportions of these crops have been sold commercially. Setting prices according to import or export parity (depending on the crop) was suggested to avoid problems stemming from inappropriate prices. To ensure that farmers would be able to sell their crops, private traders could be allowed to act as commission agents for Coop Lesotho, or trade in food grains in their own right.

(4) Fruit and Vegetable Marketing (RD-B-27)

The objective of this project was to gauge the potential to replace fresh vegetables and fruit imports with local production, and to uncover marketing constraints which would discourage farmer production. Country-wide estimates were made of the volume and seasonality of imports, local production, and self-sufficiency. The most important imports and production items were cabbages, potatoes, tomatoes, and onions. A significant potential exists to increase production for import replacement. However, it is constrained by considerable summer production, and by higher winter production costs.

Unfortunately, competitive growing areas in South Africa are frost free. Prices indicated a fair amount of competition beneficial to consumers. More research needs to be done on prices received by farmers.

Two problems identified among small farmers were a lack of familiarity with the nature of the market and its requirements, and a transportation shortage to move produce when it is ready for sale. As one remedy for the former, it was recommended that daily market information be broadcast over the radio to farmers. As another, a central market could be constructed in Maseru, and possibly other district towns. Alternative types of markets were evaluated. In the most promising, small farmers would have the choice of selling their produce either directly to consumers, or to licensed traders who would sell to consumers from stalls on the premises. Continued use of the import permit system would help limit competition when local supplies were available.

Transportation is a much more difficult problem to solve, and depends on what form government assistance to producers, if any, takes in the future. Under present circumstances the possibilities should be investigated of encouraging loans to farmers to buy pick-up trucks.

The summary of this publication was issued as a separate document, RD-B-27A.

(5) Mohair Trends in Production and Quality (RD-B-35)

This paper was stimulated by the observation that complaints have been made for at least 50 years about declines in the quality of Lesotho mohair and the average yield per goat, in spite of exhortations to farmers to improve their goat husbandry.

Available data do indicate a downward trend in quality in recent years. Average yield per goat is far below potential, but this seems always to have been the case. The reason why farmers do not respond to calls for improvements is that it does not pay them to do so as long as they graze their animals on communal rangeland. Hence, while mohair has good income potential for farmers, it will not be realized until grazing on the range is brought under control, probably through farmers' associations of one kind or another.

(6) Pricing Food Grains and Pulses in Lesotho (RD-B-31)

Food grain pricing was one of the first topics to which Wyeth devoted attention after arriving in Lesotho. A number of marketing problems had arisen when prices were out of line with those in South Africa. Several papers of varying length were written around this topic, often in collaboration with Dr. D. Bostwick of the Planning Division. This paper is the culmination of those papers.

First, the cost-plus and import/export parity approaches to pricing were described and evaluated. The conclusion was that parity pricing will avoid market problems, but although cost-plus pricing

will guarantee farmers with average production costs a rate of return, parity pricing will not. However, the variability of average rates of return will encourage farmers to grow those crops for which their local growing conditions are most suitable.

The latter part of the paper considers the relative profitability of the five staple crops under parity pricing. It also illustrates the different production patterns that could occur under cost-plus and parity pricing and the impact on agricultural self-sufficiency. While cost-plus pricing is more effective at promoting self-sufficiency in each crop individually, parity pricing reduces the overall trade deficit, because surpluses of beans and peas are exported to cover part of the cost of importing maize and wheat.

(7) Markets at the Farm Level in Lesotho (RD-B-32)

This paper supplements RD-B-5, Input and Crop Marketing in Block I, summarized above. It uses three other sets of data: a Baseline Survey in the three Research Divison prototype areas which was undertaken in late 1980; crop disposal and meal/flour purchasing forms employed in a farm records program organized by the Farm Management Section of the Research Divison in the same prototype areas; and crop disposal questionnaires administered as part of the BASP farm management monitoring survey maintained by R.J.G. Steele and T. Ncholu in Leribe and Butha-Buthe.

According to the Baseline Survey data, problems farmers encountered when thinking of buying inputs, are similar to those obtained from the earlier study in the Leribe/Butha-Buthe area with BASP. The data on crops offer additional information about sources and quantities of grain, meal, and flour acquired by farmers, and about proportions going to consumption, sales, and a variety of other uses. All three sources show small numbers and amounts of grain sales and wide price differences. However, farmers did not complain that sales were difficult to make. Most were to neighbors at prices above official levels. The BASP study data supports the idea that sales are meager because production is low rather than because marketing is problematic. Nevertheless, markets should be monitored and improved where necessary because, as development proceeds, output should grow beyond the absorption capacity of local markets. Commercial channels must perform well to prevent marketing bottlenecks.

c. July 1984 to June 1986 (Brokken)

Three main research projects were undertaken during this period.

(1) Marketing Hides and Skins in Lesotho

The potential value of sheep and goat skins is approximately 1 million maloti per year, while cattle hides could be worth approximately M2 million per year. Currently the few the hides and skins that are marketed are of very low quality. While the total value of hides and skins is not great, the benefits from increasing the

quality and quantity marketed would be widely dispersed among farmers, and ought to be attainable at relatively low cost.

Improving the quality through dry salting could increase the value of hides 4-fold, and the number collected might be increased from 3-8 times.

Extension Programs and Materials. Slide/tape and video programs on flaying and curing hides and skins were produced. Assistance and cooperation in developing a script for this program came from the African Hides Trading Corp., Port Elizabeth; the Leather Research Institute, Rhodes University, Grahamstown; Instructional Materials Resource Center (IMRC), Ministry of Education; the Information Division of the South African Department of Agriculture; and the Livestock and Research Divisions, Lesotho Ministry of Agriculture. The Marketing Section coordinated the activities and made arrangements to do the filming in a Lesotho villlage. The Information Division, RSA Dept. of Agric. prepared a slide tape program and IMRC prepared a video program. This program has been shown in the prototype areas and was received enthusiastically. Partial funding for the development of the slide/tape program was provided by SARCUSS (Southern Africa Regional Commission for Conservation and Utilization of the Soil).

Two extension handbooks, one in English and one in Sesotho, on the proper methods of flaying and curing hids and skins were written. Three thousand copies of the Sesotho illustrated handbook (8 pages) will be distributed to villages through Lesotho.

Training Schools on Flaying, Curing, and Grading of Hides and Skins. A 1-week training school for flaying, curing, and grading hides and skins was organized by the Marketing Section. Two district level extension workers, the District Livestock Officer. and District Livestock Assistant Officer from 9 of the 10 districts participated.

Workshop on Improving Marketing of Hides and Skins in Lesotho. The Marketing Section organized a workshop to generate ideas to improve efficiency of hide and skin marketing in Lesotho. It is expected that a range of ideas will be forthcoming about the best way to improve hide and skin marketing. Resolving conflicting proposals is not an objective, rather, these ideas will be openly discussed. The conference proceedings will be recorded and summarized for publication. Those invited to make formal presentation are: Marketing Section (Research Division); Livestock Products Marketing Service; Lesotho National Development Corporation; National Abattoir and Feedlot Complex; two Maseru-based private hide and skin companies, Basotho Tanning and Lesotho Hides and Skins Brokers (these are both relatively new in the business); Farmer Cooperative Brokers (BKB), who regularly conduct sales at Port Elizabeth for international buyers of wool, mohair, hides and skins; G. H. Hackman and Company, Durban; and African Hide Trading Corporation, Port Elizabeth.

In addition observers have been invited from the Ministry of Agriculture headquarters, Planning Division, Livestock Division, Range Division, Agricultural Informantion Services, USAID, ISAS, UNDP, FAO, and EEC.

(2) Farmer Level Extension Program in Vegetable Marketing

This project was a response to a May 1985 request from farmers in the Nyakosoba prototype area for help with marketing an atypical bumper vegetable crop. The farmers had reponded to recommendations from the Research Division Extension Section to plant more vegetables, and reasoned that the Research Division should help market the surplus. This was the first time they had produced a surplus so large that it had to be marketed outside of the village area. They had little understanding of potential market outlets, of how to arrange transportation, and of what prices to expect. They did not understand the costs and services involved in the formal marketing system, and argued that they should be paid the same prices for their vegetables as they would pay for them in the local store. They were sure that the prices being offered were unfair, and insisted that they would let the vegetables rot in the field if they could not get the same price as they would pay in the local retail store.

Mrs. Motsamai and Miss Moletsane did an outstanding job of showing the farmers their options and explaining the reality of their situation.

It was obvious that if the farmers were to continue to produce significant seasonal surpluses, they needed to learn more about marketing. A program was designed to teach small vegetable farmers about marketing. This program is being conducted in the prototype areas now. The program:

- Provides information to farmers on price variability by commodity, season, and different quality grades.
- Acquaints farmers how to use this information to make decisions about what vegetables to plant and when to plant them.
- Provides information on what farmers can do to enhance and maintain quality during both production and marketing.
- Acquaints farmers with alternative market outlets for their produce. This includes organizing field trips to give farmers a firsthand look at the various outlets.
- Acquaints farmers with steps that must be taken to arrange reliable timely and transportation.

An extension pamphlet covering these items is being prepared. A survey of vegetable production and marketing in the three prototype areas is also underway.

(3) Analysis of Livestock Production Marketing and Slaughter in Lesotho

The overall objective is to provide public and private decisionmakers in Lesotho with economic insights critical to the development of the Lesotho livestock industry. There are several subobjectives:

- Evaluate the total contributions of Lesotho's cattle, sheep, and goat populations to the domestic economy. Total value will be composed of the values of stock (meat, offal, hides, and skins); flow (milk, draft, dung, progeny, wool, and mohair); financial (savings, liquidity, store of wealth); sociological (mafisa, bohali); and psychological (prestige, status) products of livestock. Values of these products are likely to vary, and therefore must be evaluated separately, with the type of farming system and the economic and demographic characteristics of the farm manager and his family.

- Determine the economic, biological, and sociological variables key to the decision making of the Basotho stockholder, and likely responses to changes in those variables.

- Examine the importance of animal draft power in the stock-holding behavior of the Basotho and making meaningful offtake comparisons and analysis. Interrelationships of cattle and crops are likely to vary with the type of farming system and the availability of draft animals.

- Examine the utilization patterns of animals dying from natural causes. An understanding of the value of a fallen animal is critical in Lesotho where most animals leave the range due to death by natural causes. Taking account of the utilization of fallen animals is also important in calculating meaningful offtake rates.

- Determine the importance of livestock as financial assets. If cattle, sheep, and goats confer utility as exchange and savings mechanisms, then they can be compared to alternative mechanisms with respect to riskiness, rate of return, and liquidity.

- Examine interrelationships between land tenure, labor, capital, and organizational constraints, and their effects on stock holding behavior. The Lesotho land tenure system is often cited as the major factor affecting the stocking rate and the perceived overstocking. Studies conducted elsewhere in Africa raise some question of the persuasiveness of the tenure factor. Labor, capital, and organizational constraints have been cited as being offsetting factors to the communal tenure system.

- Examine both formal and informal markets for livestock and livestock products.

o Prescribe policies apprropriate to meeting development objectives in the livestock sector.

A 56-page questionnaire was administered to 549 livestock-owning households in 18 randomly selected population census enumerated areas during the winter (July, August, and September) of 1985. Preparing the data for computer analysis has required 12 coders and one supervisor working from November to April. A progress report of the survey will be included in Vol. II of this report.

(4) Recommendations

The analytical and research capability in marketing research should be maintained, and Research Division Marketing section personnel strengthened. Currently there are two research officers in the Marketing Section. Mrs. Motsamai received a B.Sc. from Washington State University in agricultural economics in June 1984 and heads the section. Miss Moletsane has a B.Sc. from the National University of Lesotho in science and has been in the section since 1981. Both have participated in research and authorship of research reports under leadership from expatriate marketing specialists.

The marketing specialists have analyzed a wide range of problems dealing with important policy and marketing issues during the 7-year period. Reports have been read and considered in setting policy and deciding marketing issues. The reports have dealt with pricing policy, and analysis of existing or optional marketing arrangements for agricultural inputs, grains, pulses, vegetables, wool and mohair, hides and skins, and livestock. An analysis of the impact of market organization, or lack of it, on crop production was undertaken. Analysis of abattoir pricing policies and options in meat distribution in controlled marketing area were analyzed.

Three of the projects are still underway: (1) an extension educational program to improve the quality of hides and skins, (2) extension education program on vegetable marketing, and (3) the analysis of livestock production, marketing and utilization in Lesotho. The two national marketing officers are fully capable of carrying out the extension education programs, and following computer training, will be able to summarize most aspects of the livestock survey. Further, they have learned much about development of survey questionnaires, selection of population samples, conducting field surveys, and coding data. It is recommended that one of the marketing officers pursue graduate training in marketing economics. Such training and experience will aid in the analysis of large data sets, such as the Livestock Survey, and the formulation of appropriate policy recommendations based on the analysis. The capability of the Marketing Section would be significantly reduced if one of the marketing officers were to leave for graduate school, but the continued assignment of a senior level Ph.D. advisor would contribute to the research capability in three important ways:

- The advisor contributes directly in terms of his/her direct output.
- The national colleagues can accomplish more working as a team with a senior level advisor.
- The national research officers can gain experience and training much more rapidly working under the leadership of an experienced marketing economist.

10. Extension

Farming systems research is an approach to agricultural development in which farmers join scientists in mutual, interdisciplinary problem-solving activities on farmers' lands. In that context, extension education plays a vital role in the dissemination of information and the diffusion of innovations.

The farming systems research and extension strategy has been at work in Lesotho since 1979 as a fully integrated program in the Research Division of the Ministry of Agriculture and Marketing. Funded by the United States Agency for International Development, faculty members of Washington State University worked as advisors and colleagues with national officers and members of farming communities to carry out appropriate activities.

Extension education programs have been conducted among a number of clienteles since 1981, addressing such areas as rural organization, village leadership, extension methods, and technical agriculture. Members of organized farmer contact groups as participants and diffusors, village chiefs and headpersons, and government extension workers and subject matter specialists were three key target groups for extension education programs.

This report concentrates on a threefold task. First, it reviews and substantiates the role and dynamics of extension education in agricultural development, as reflected in farming systems research activities in Lesotho. Second, it assesss the impacts of extension education programs in the above context in terms of changes in knowledge, attitudes, skills, and aspirations (KASA), agricultural practices, and where possible, end results. It uses a reflective appraisal of programs (RAP) methodology to ascertain those outcomes. Third, it formulates conclusions and recommendations to improve future programs based on the evidence thus derived, together with any other discoveries made during the course of the evaluation.

Basing this evaluation on the extension segment of the farming systems research intervention in Lesotho, the outcomes demonstrate that there have been impressive, at times dramatic, KASA changes among the three key clienteles. Likewise, practice change in all three groups, while more variable, was significant as described by the participants themselves. Finally, end results, best seen among the farmer contact groups, disclosed such real benefits as better meals

for families, higher crop yields, improved condition of animals, and increased incomes. The members of those same groups became effective disseminators, each reaching nearly nine other farmers.

While farming systems research is neither a panacea for low productivity nor a blueprint for Africa, it is a useful strategy. As in other strategies, extension education is both central and critical to dissemination of information and diffusion of innovations. Extension education programs, designed according to available resource levels, do produce positive change in participants' learning, practical behavior, and end benefits. Women, as a dynamic human resource in the development formula, must be considered in the design and delivery of extension programs. And, urgent research into extension education for the developing world is required so that new, flexible, and realistic methodologies might be perfected to meet urgent challenges.

Extension education programs in Lesotho, carried out in conjunction with a farming systems research development strategy, had measurable and demonstrable impacts on three key target groups in that country's agriculture. These were farmer contact groups, headmen and headwomen, and district-based extension workers and subject matter specialists.

Extension education was studied as that form of nonformal education developed within, and specifically for, the agricultural environment. Inquiry into the farming systems research strategy established that there is no stage in which extension education is not ideally involved if desired change is to take place and endure. The active role extension education has played in the Lesotho Farming Systems Research intervention confirms that relationship.

The impact of extension education programs on members of farmer contact groups in the Farming Systems Research prototype areas became evident in self-perceived changes among members in their knowledge, attitudes, skills, and aspirations levels in the subjects that were taught. Evidence of positive impact was found in reported practice changes in such areas as agronomy, horticulture, pest control, farm machinery, and rural leadership. This impact was even more significant in terms of real benefits, such as better meals for farm families, higher crop yields and income from farming, and the ability to acquire better farm inputs.

The effectiveness of farmer contact groups as an innovation diffusion network and as disseminators of agricultural information was good. The data indicated an approximate nine-fold multiplier effect for three diffusion modes studied.

Basotho chiefs and village headmen and headwomen perceived generally enhanced KASA change levels in several subjects taught in extension short courses, and a similar reflective profile for changes in their practices as village leaders. However, in some subjects, especially range and livestock, this clientele reported no recall

and/or low learning rates, resulting in negligible practice change. The data do not suggest the underlying causes. At the same time, these same traditional leaders benefited significantly from the extension education programs and were unanimous in their support for farming systems research as a development strategy.

District-based extension workers and subject matter specialists in Lesotho also reported a widespread positive impact of Farming Systems Research extension education programs in the many subjects taught. As might be expected, among a more educated and discriminating group, there was higher variablility in perceived levels of attainment in the subject matter in question. The group was likewise variable in subsequent practice changes which could be related to the extension education programs. However, the examples described represented real breakthroughs in the demonstrated expertise of those involved.

Other findings were discovered or formulated during the study which are relevant to the development and improvement of future Farming Systems Research and extension education programs.

Farming systems research is a useful strategy in that it is interdisciplinary, and it engages the farmer directly in the dynamics. The paradigm, as developed by the principal proponents (mainly agricultural economists) seems to have assumed too much homogeneity of small farmers, their access to resources, their likemindedness, and their propensity toward adoption of "packages" or integrated farming schemes. The Lesotho experience indicates something else. Farmers are heterogenous with respect to access to resources and the propensity toward change. They do adopt innovations, but they do not voluntarily adopt packages. They pick and choose bits and pieces from a wide array of recommendations and are prompted by such factors as affordability, family priority, personal resources, cultural or traditional values, risks involved, and personal inclination. There seems to be little behavioral uniformity among the farm clientele. Adoption takes place through selective individual decision making, but cumulative or collective practice change or adoption of innovations may still be significant over time.

Extension education is a necessary component in the agricultural development formula. Much literature evolving from the frustrations of failed development efforts blames infrequent success on ineffective extension systems. However, pretending that extension education is not necessary is to "pretend away" a vital link in the agricultural innovation continuum. Rather, extension education must be flexible, modifiable, and adaptable to local resource levels in order to be successful. The Lesotho experience is a testimony to this.

Extension education is an art. As other arts respond to and are influenced by their times and environments, so too is extension education. Successful extension education depends on a subtle and delicate relationship between educator and student in which both learn from each other. The relationship is never static. Voiced

constraints to extension successes frequently dwell on insufficient materials, support, and rewards for extension educators. As there is no environment so severe as to stifle art, there is likewise no environment so impoverished as to prevent useful learning. Extension education can happen anywhere if it is scaled to the resource availability of both extension workers and farmers.

The Lesotho study demonstrates the existence of an "extension effect", a dynamic process in which gains in the enhancement of knowledge, attitudes, skills, aspirations, practice change, and real benefits related to any agricultural innovation rise in direct proportion to the intensity and frequency of extension education programs.

The position, so frequent in the literature, that extension education programs in the developing world are designed for and directed at men is not corroborated by the Lesotho Farming Systems Research and extension education experience. To the contrary, women farmers constituted nearly 75% of the farmer contact group membership and were responsible for most of the documented innovation. Women held 45% of the chiefs and headperson positions, and were among the more proactive in post-educational rural leadership. Women accounted for 30% of the district-based corps of agricultural professionals who participated in extension continuing education programs, not only in domestic economics roles but also in agricultural responsibilities. The extension programs assessed in this study were not only designed to recognize a strong female presence, but also reaped the rewards represented by that dynamic human resource.

It is significant that, in this evaluation, Claude Bennett's (1982) reflective appraisal of programs (RAP) evaluative methodology was tested in a developing world setting, specifically a rural African setting. All the conditions necessary for the use of RAP prevailed. The response scores were uniformly quite high, higher than would have been seen in an American or European setting. They were highest among farmers, tending toward greater variability among chiefs, and even more so among professional agriculturalists. This could be interpreted by some as bias or unsubstantiated optimism. It is interpreted in this research as something else. The opportunities for direct participation in extension education programs for farmers in rural Lesotho are infrequent, while other factors of the daily environment are grossly routine. When extension educators arrive in an area to conduct a course, the event as well as the content represents a unique departure from the routine. Thus, the things that are learned, be they knowledge or skills, are magnified and become reflected in subsequent perceptions. Those same perceptions are reported with more enthusiasm and optimism among chiefs or extension workers who are exposed to greater numbers of change agents, and who have a wider range of educational opportunities. It seems that the RAP methodology can be influenced by the environment in which it is used. That does not alter the fact that perceptions are being reported precisely as the participant sees and feels them. The more educated and more exposed the clientele, the more moderate and

variable will be the responses. But, if learning is perception, then the RAP methodology retains its validity as well as its reliability.

A final conclusion is that more research into extension education in the developing world is desperately needed. The literature is rife with agricultural research findings, economic concepts, and unsubstantiated and uncorroborated pronouncements about the worth of extension education in the development formula. There are reports of extension education successes and education failures. Unfortunately, not enough is known about either.

The world's resource base will come under increasingly severe pressure in the coming years. It is certainly reasonable to suggest that the evolving field of extension education can contribute to a reduction in that pressure.

C. General Summary

This section includes brief highlights of significant accomplishments and recommendations for future programs. Some of the problems encountered are implied in the recommendations sections.

1. Administration

a. Accomplishments

- The formation and initial development of a viable, though still immature, Research Division.
- Training of 20 nationals to B.S. and M.S. levels.
- Initial development of an Agricultural Research Library--the most complete in the country.
- Effective support and coordination of RD/FSRP programs.

b. Recommendations

- Prepare a written policy statement, which clearly defines the functions of the Ministry and the Divisions.
- Form a committee to make management decisions concerning the operation of the Research Farm and substations.
- Implement an annual budget/program meeting.
- Make provision to seek outside research funding for the Director's office.
- Continually interact with other Divisions in the Ministry.
- Develop country-wide priorities for agricultural development with input from each division. Programs should be based on "bottom-up" not on "top-down" approach.

2. Rural Sociology

a. Accomplishments

o Development and implementation of the Baseline Survey. This was a major contribution of the project which was successful, among other things, in providing a quantative description of prototype area farming practices, social structure, and identifying social, economic, and technical constraints to production and income.

o Orientation of other Sections to cultural norms and constraints. This was an important prerequisite to undertaking research and educational activities in rural areas by each Section.

o Effective training programs for VACs in cooperation with the Extension Section.

b. Recommendations

o That Rural Sociology be a fully supported unit of RD and of any future projects.

o That in future projects, a brief preliminary survey be conducted the first few months, a regular Baseline Survey be conducted the second year, and a final brief survey be conducted the last year to see if any change can be measured. The results of the Baseline Survey should be tabulated, summarized, and fully utilized by each Section.

3. Farm Management

a. Accomplishments

Publication of research reports on:

o The agricultural setting in Lesotho--the historical and economic development of agriculture.

o Enterprise budgets. Costs and return studies for tree fruits, irrigated vegetables, and asparagus.

o Costs and returns associated with field crops grown by combination farmers.

o Irrigation Projects in Lesotho: An Historical Analysis.

b. Recommendations

o That a Farm Management Economist be maintained at the RD until national personnel are trained to where they can assume responsibility.

o That all research publications be carefully reviewed with a view toward further research in the same areas.

4. Soils

a. Accomplishments

- Development of a soils lab that is reasonably well equipped and has excellent supervision, but needs more space.
- Compilation of current information on soils of Lesotho, the soil erosion/conservation situation, and evaluation of soil fertility management programs.
- Publication (in press) of a Soil and Water Management Guide for Lesotho.
- Data from the Agronomy and Horticulture Sections showing strong responses to N and P.

b. Recommendations

- That there be a separate Soil and Water Management Section within the RD.
- That there be a special effort in research and education to address the entire issue of soil erosion/soil conservation. This could be a combined effort between Conservation Research and Range Divisions.
- A special research effort be directed to solution of problems of Duplex soils, low pH, and other special soils problems.
- A soil test correlation research program be given much greater emphasis.

5. Agronomy

a. Accomplishments

- Dramatic demonstrations of yield potential in Lesotho, resulting from improved practices with special reference to crop varieties, soil fertility, weed control, land leveling, soil preparation, plant population, fall planting, and simple improvements in farm equipment.
- The introduction of pinto beans to replace, under certain conditions, white haricot beans. Pintos are lower yielding but shorter season, allowing for less risk from hail, early frost, and CMR beetles.
- Positive changes (reported in Section III-J, Extension) show in terms of knowledge, attitudes, skills, aspirations, and practice changes of Basotho farmers.

b. Recommendations

- That fewer on-farm research trials be conducted and more of these be located on-station, where there is better control. In any case, whereever trials are located, the researcher must have control.

- That a vigorous education and demonstration program be conducted during the next few years using the agronomic data obtained during the Project.

6. Horticulture

a. Accomplishments (during 1984-86)

- Dramatic yield responses to fertilizer on potatoes. Also responses to irrigation and chiseling treatments.

- Significant data on effects of variety, fertilizer, irrigation, and plant spacing on production of potatoes, cabbage, tomatoes, onions, beetroot, and pumpkins.

b. Recommendations

- Much research remans to be done to improve the basis for establishing a really viable domestic vegetable industry.

- Emphasize research on economic evaluation of input levels and practices.

- Work on improvement of infrastructure for transportation, marketing, and storage of vegetables.

7. Range Management

Overgrazing is the range problem that overrides all others.

a. Accomplishments

- Careful examination and evaluation of the overgrazing problem was made by FSRP workers.

- Data indicate forage requires several years to recover.

- Some important data were obtained on improving range assuming range is not overstocked. Examples were: introduced species, range burning, brush control, and range resting.

- It was demonstrated that farmers were willing to cooperate in rotating pastures.

b. Recommendations

- Make long-term grazing management plans based on climate, soils, and vegetation data to date.
- Move toward the formation of grazing associations and include a grazing fee.
- Continue ongoing research, but not at the expense of the overstocking problem.

8. Animal Science

a. Accomplishments

- There are indications that some developments are occuring that will influence animal production, even though they are relatively insignificant at the present time. The increasing farmer interest in growing animal feed to supply animals with better quality supplements, the formation of several herd improvement associations, and recognition among villages that something must be done about the condition of their animals are all indications that, with educational programs, changes will occur.
- Demonstrated advantage of feeding concentrates to oxen in winter. Enthusiastically accepted by prototype area farmers.
- Farmers willing to spend money on fodder crops. Formation of a fodder association with 60 farmers on 20 ha.
- Demonstration of performance improvement: reproductive rate and wool production increased with better nutrition.
- Demonstration that farmers could successfully produce eggs.

b. Recommendations

- Develop alternative sources of draft power.
- Develop roads, transportation systems, storage facilities, and marketing systems.
- Develop a fair enforceable method to regulate grazing animals.
- Continue educational programs.

9. Marketing

Marketing was a very important segment of the Project for the entire time 1979-86.

a. Accomplishments

o Agricultural marketing systems and policies were analyzed and systems of inputs, crops, livestock, and livestock products were described. Commodities studies were: wool and mohair, fruit and vegetables, food grains and pulses, hides and skins, livestock for slaughter.

b. Recommendations

o Maintain the present marketing analytical and research capability.

o Assignment of a senior Ph.D. level advisor to the Marketing Section.

10. Extension

a. Accomplishments

There were KASA changes among the key clienteles. Also, positive practice change, while more variable, was significant as described by the participants themselves. End results, as seen among the farmer contact groups, described such real benefits as better meals for families, higher crop yields, improved condition of animals, and increased incomes. The members of these groups became effective disseminators, each reaching nine other farmers.

b. Recommendations

o The positive results from the Extension program clearly indicate the importance of continuing the same type programs with few changes.

o More research is desperately needed in Extension education in the developing world.

11. Concluding Comments

The major accomplishments of the Project are invested in three areas:

o human capital,

o physical and institutional capital, and

o a knowledge base for agriculture in Lesotho.

Training Nationals in agricultural science will have the most lasting impact of all project activities. It will be necessary to expand this base in future projects, but at least a foundation of human capital has been established. In this sense the project has made an important contribution to the future development of Lesotho.

The physical capital necessary to the development of meaningful agricultural research is now well established. The necessary buildings, office and lab equipment, machinery, computers, etc., at the main research station are in place. The vehicles required to conduct on-farm research are on hand and the required housing in the prototype research areas has been built. While future expansion and improvement of the physical plant will of course be necessary, the existing base is adequate to carry on high quality agricultural research.

Probably even more important than physical improvements are the institutional developments. Outstanding examples are the Research Division, the library, and the soils lab.

Finally, a significant program of agricultural research has now been completed. The technology resulting from this research has been recorded and published. This knowledge base has been widely disseminated throughout the Ministry of Agriculture and maintained on permanent file in the Research Division library. For the first time there is now a consistent and accessable record of past research. The knowledge base on Lesotho agriculture has expanded tremendously during the course of the project. What this means for the farmers and extension workers is that accurate and tested information on improved agricultural technology is available. This is good reason to believe the result will be improved agricultural productivity, as well as improved agricultural research in the future.

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II. The Situation Before 1979*

A. The Economy in 1978

Lesotho is a small, landlocked "Mouncain Kingdom", completely surrounded by the Republic of South Africa (RSA). With an area of approximately 30,000 km^2, it is about the size of Belgium, or roughly one-sixth the size of Washington state. The population in 1979 was slightly over 1.2 million (estimated at 1.5 million in 1986), 85% of whom are rural residents, mostly in the lowlands. Only 13% of the country (approximately 400,000 ha) is considered arable. Most of the cropped land is in the western lowlands and foothills regions, which occupy roughly 30% of the total land area. Rangelands occupy most of the mountain region--about 70%. Elevations range from less than 1,400 meters in the lowlands to more than 3,500 meters in the eastern mountains.

Lesotho's climate is pleasant most of the year. Summers are warm, but usually not hot, and winters are moderately cold with only light frosts in the lowlands, but colder in the mountains. Most of the rainfall is during the growing season, October to March. Average annual rainfall, ranging from 600-1,000 mm, is sufficient for reasonably good production of the major crops (maize, sorghum, wheat, peas, and beans), but high climatic variability portends high risks. In some seasons, rainfall is marginal or submarginal for crop production, and severe droughts occur every few years.

Agriculture in Lesotho is largely of a subsistence nature. Some 85% of the population derive income from agricultural activities. If 56% of the labor force works in the country, fully 92% of those are employed in agriculture. Principal crops are maize, sorghum and wheat. Cash crops include beans, peas, and some wheat. Livestock are principally cattle, sheep, and goats. On-farm consumption accounts for 70% of crop production.

Animal and farm products make up 70% of Lesotho's exports, while crops, largely wheat, account for another 6%. Lesotho produces roughly one-half of its food supply. Because of the country's communal land tenure system and the widespread incidence of migrant labor, uniform rural income is a unique phenomenon (USAID, 1978, p. 2).

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* Much of Section II is a condensed adaptation of LASA Research Report No.2: Lesotho's Agriculture, A Review of Existing Information. Lesotho Ministry of Agriculture and Department of Economics, Colorado State University, 1978. Section II is an overview of the situation prior to the beginning of the FSR Project in 1979. All tables are from LASA, 1978, as published or adapted.

Constraints to agricultural productivity thus include severe weather conditions, limited arable land, serious land erosion, and some traditional farming practices. Inadequate use of fertilizer, low quality seed, poor tillage, lack of pest control, improper weeding, wasteful harvesting methods, and post-harvest losses all contribute to low crop productivity. Improper range management, overgrazing, lack of supplemental feeding, diseases, and poor management affect both animal productivity and the quality of the resource base. It was most of these problems that farming systems research and extension work sought to address.

1. Resources

Lesotho is poorly endowed with natural resources--especially those resources normally considered essential for a solid economic base. For example, there are:

- essentially no mineral deposits except for some diamonds, but there are, however, large quantities of sandstone suitable for use as a building material;
- no known petroleum deposits; and
- only 13% of the total land area is suitable for crop production.

However, Lesotho does have two valuable resources: watersheds and grasslands. The mountain region is the source of the principal rivers of South Africa. For example, both the Orange and Caledon rivers originate in the mountains of Lesotho. Large volumes of water, along with the wide differences in elevation, give Lesotho an enormous potential for hydroelectric power for domestic use with considerable surplus for export. Strangely, although this potential had at times been seriously considered, and although Lesotho's demand for power was increasing at an annual rate of 30%, this resource had not been developed and, as of 1978, was not even close to the planning stage.

Considering the amount of water available and the periodic droughts that plague agriculture, supplemental irrigation would seem to have considerable potential. A number of donor countries have been involved in irrigation development in various parts of Lesotho, but the number of hectares of irrigated agriculture was still very small. Some studies have indicated the economic advantage may be marginal. One severe problem is the heavy sediment load of rivers and streams, which leads to rapid wear on pumping equipment, high costs of maintaining silted reservoirs, and other problems.

The other valuable resource is grasslands. Most of Lesotho is within one of the most productive grassland areas in the world--the highveld of Southern Africa. Production capacity and regenerative capacity were high. There is general agreement that the ranges of Lesotho were producing well below their potential, and population and livestock pressure were evidently major factors contributing to soil

erosion and reduced range productivity. The erosion problem is discussed in some detail in Section III-D (Soils) and is summarized in I-B-4.

2. Economic Setting

Lesotho's economy is inseparably linked with the economy of the Republic of South Africa (RSA) (Table II-1). The economy, measured by any of several standards, grew tremendously in the 10-year period 1969-78. The growth in Gross Domestic Product (GDP) and Gross National Income (GNI) are readily seen, along with the growth in migrant remittances from the more than 50% of the labor force working in RSA, usually in the mines. There was also a large increase in both exports and imports, but more importantly, the growth of imports greatly exceeded the growth of exports leading to a trade deficit of R170 million in 1978. This figure alone was cause for concern.

Only a glimpse of the migrant situation is required to appreciate its importance in the overall economic situation. Lesotho's workers, ages 18-60, were estimated to be employed in these categories:

Agriculture	28%
Non-agriculture	7%
Unproductive	5%
RSA	60%

Approximately 200,000 Basotho were employed in RSA, mostly in the mines. Even assuming that farm production would increase if migrant workers return to the farm and provide more badly needed labor/management inputs, a rapid transition in this direction would be disastrous, at least for the short term.

Commodity prices in Lesotho are comparable to those in RSA. But the average RSA farmer operates 1,230 ha with heavy capital investment. Even if per hecatre yields and general production become comparable, the Mosotho farmer with 2 ha obviously cannot compete, and it is likely his net income would not equal the returns of a migrant laborer.

A cause for concern is that, while migrant labor remittances are an important part of the GNI, this amount is not likely to increase in the next few years, and may decrease. Lesotho is completely subject to RSA policies for this source of income. For example, RSA is likely to employ more miners from within its own borders, with a corresponding decrease in migrant laborers.

Although the GDP and GNI grew substantially (Table II-2), either as indicated by 1977/78 prices or by 1968/69 prices, GDP growth was small compared to the growth in GNI, because of migrant workers' wages and the increase in numbers of migrant workers. Another important inference is that the small increase in agricultural production and the low level of production was in part, a result of large land areas left fallow each year because of labor shortages and the lack of incentives to invest in the farm operation.

During the period 1973/74-1976/77, in terms of GDP, agriculture grew very little compared with the country's total GDP (Table II-3). During this period, agriculture declined from approximatedly 51 to 41% of the total. The conclusion from Tables II-1 to II-3 is fairly obvious: aside from migrant workers, Lesotho is primarily an agricultural country, and must find ways to increase efficiency. Increasing both production and efficiency would certainly help achieve the ultimate goal of the project: to improve the quality of rural life. It is important to note that more than half of Lesotho's food must be imported--mostly from RSA, again making Lesotho heavily dependent on the economy of that country.

It is apparent that concurrent with the objective to improve the quality of rural life, is the national objectives of economic growth and economic independence. These were given priority when the second 5-year plan (1975-80) was prepared. Specific objectives for agriculture were:

For crop production:

- To foster general yield and production increases but specifically to achieve net self sufficiency in basic grain and vegetable production. A 38% increase in agricultural output was targeted.
- To increase crop derived income (wheat, beans, forage crops), to support livestock production, and to introduce potatoes and asparagus.
- To bring efficient input supply and producer-oriented market organization to the village level.

Table II-1. Gross domestic product and gross national income for Lesotho: composition and growth rates. (Thousand rand units at 1978 prices).

	Base 1967/68-1969/70	1977/78	1977/78 as % of base	Compound growth rate
Exports of goods and services	3,750	40,000	1067	30.1
Imports of goods and services	-23,664	-210,000	887	27.5
Gross domestic product	44,448	139,350	311	13.4
Migrant labor remittances	11,627	117,420	1010	29.3
Gross national income	56,975	255,770	449	18.2
Exports minus imports	-19,914	-170,000	854	26.9

Source: Bureau of Statistics, 1978 (as cited in LASA, 1978).

Table II-2. Estimated real per capital gross domestic product and gross national income for Lesotho.

Year	Current prices GDP ('000)	Current prices GNI ('000)	Price index (1968/9) = 100)	1968/69 Prices GDP[1] ('000)	1968/69 Prices GNI[2] ('000)	Pop ('000)	Real per capita (GDP	Real per capita (GNI)
1967/68-1969/70	44,448	56,975	100	44,448	56,975	1,017	43.70	56.02
1970/71	49,060	63,127	108	45,426	58,451	1,164	42.69	54.94
1971/72	54,683	70,228	115	47,550	61,068	1,088	43.70	56.12
1972/73	62,216	82,894	124	50,174	66,850	1,112	45.12	60.12
1973/74	71,480	101,163	139	51,424	72,779	1,138	45.19	63.95
1974/75	78,490	138,350	157	49,994	88,121	1,163	42.99	75.77
1975/76[3]	77,390	167,360	179	43,235	93,497	1,190	36.33	78.57
1976/77[3]	104,790	207,450	199	52,658	104,246	1,217	43.27	85.66
1977/78[3]	138,350	255,770	231	59,892	110,723	1,244	48.14	89.01
9-year annual growth rate (%)	13.4	18.2	9.7	3.4	7.7	2.4	0.9	5.3

1. Gross domestic product.

2. Gross national income.

3. Preliminary.

Source: LASA, 1978.

- To improve supply through support of oxen and tractor-powered mechanization.
- To increase the quality of the extension service.
- To foster a production and market-oriented crop research program.

For livestock production:

- Raise productivity, particularly through improvements in nutrition, breeding, disease prevention, and general management.
- Raise value added within the nation through better marketing and processing.

These objectives, formulated in 1975, support and complement very well the FSRP objectives to increase the quality of rural life.

B. Physical Resources

Physical resources, such as climate, soil, and water, heavily influence crop and livestock production, even when using advanced technologies such as commercial fertilizer, improved soil management, and irrigation. Farmers must manage the natural resources and operate within their limitations for both short-term and long-term advantage. An understanding of those resources is also essential to understanding a 7-year project.

Table II-3. Lesotho gross domestic product at factor cost, 1973/74 to 1977/78 (in millions of rand, - 1978 prices).

	1973/74	1974/75	1975/76	1976/77
Agriculture	35.45	35.15	36.69	43.62
Crops	(19.28)	(17.07)	(18.87)	(24.54)
Livestock	(16.17)	(18.08)	(17.82)	(19.08)
Mining and quarrying	0.24	1.10	1.69	2.69
Manufacturing	1.83	3.15	2.60	2.30
Building and construction	1.66	0.99	2.59	5.31
Transport and communication	1.68	2.12	2.10	2.91
Government	6.59	6.29	9.30	11.50
Ownership of dwellings	7.59	8.57	8.83	10.90
Catering	2.00	2.37	4.33	6.07
Wholesale and retail trade	6.54	10.81	12.05	14.20
Other	5.33	5.19	4.08	5.80
Total	68.91	75.74	85.26	105.30

Source: LASA, 1978.

1. Climate

The important factors of climate are precipitation, temperature, and evaporation. Mean values for these factors are favorable for good production under good management in Lesotho. The main production problems are not related to mean values as much as to deviations from the mean. Periodic drought periods, heavy rainstorms, early fall and late spring frosts, hailstorms, and periods of hot, dry weather with excessive evaporation, all of them unpredicatable, are the main climatic problems that plague farmers. These vagaries seem to be a special problem in Lesotho.

a. Precipitation

Mean annual precipitation ranges from 600 mm in the lowlands to as high as 1,300 mm in the mountains. However, aside from the high mountains in the eastern part, most agricultural areas receive from 600-900 mm (Table II-4). Approximately 80% of the annual precipitation falls during the 6-month summer period.

Long term records indicate annual precipitation can vary from 50% below to 50% above the mean. These variations become critical when the mean is barely adequate for good production. In addition to the certainty of periodic droughts, another problem is heavy rains that cause flooding and erosion, especially on soils with poor infiltration. This is covered in more detail in Section III-D (Soils).

Hail storms are an ever-present threat to Lesotho crops; each year thousands of hectares of crops are damaged or destroyed. Many locations receive hail several times in one season, but the location and timing of hail storms are of course unpredictable.

b. Temperature

Temperature variations by location in Lesotho are closely related to elevation. Latitude differences are insignificant. Thus in rough figures, the mean annual temperatures in the lowlands are near 14°C with a mean monthly range of 7-20°C. For the mountain area the mean annual temperatures are near 12°C with a range of 5-17°C (Table II-5).

Mean monthly and mean annual temperatures are not always useful. In descriptive terms, lowland daytime temperatures are comfortable for much of the year. Summers are warm but not hot, with maximum temperatures seldom higher than 35°C. Winters are mild with nighttime temperatures reaching slightly below 0°C with light frosts. In the mountains, of course, summers are cooler and winters are somewhat colder than in the lowlands. Lesotho has a long frost-free growing season for essentially all agricultural areas (Table II-6).

c. Evaporation

Evaporation, although not always considered in climatic data, is nonetheless important for agriculture. The effective moisture for crops depends on the amount of evaporation as well as the amount of rainfall (Table II-7).

Pan evaporation, while not intended as a precise measure of evapotranspiration, is closely associated with it. When the data in Tables II-4 and II-7 are compared, evaporation exceeds precipitation every month of the year, and the total annual evaporation is three to four times that of annual precipitation.

Table II-4. Average monthly precipitation (mm), Lesotho.

													6 Mo winter		6 Mo summer	
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Tot	Amt	%	Amt	%
Lowlands																
Butha Buthe																
12	14	27	78	99	110	127	107	105	58	30	13	780	154	20	626	80
Leribe																
13	13	30	76	104	117	132	115	112	60	34	13	819	163	20	656	80
Teyateyaneng																
11	12	22	68	90	93	111	93	99	57	31	11	698	144	21	554	79
Maseru																
12	13	21	61	88	89	108	91	99	60	29	11	682	146	21	536	79
Wepener																
12	12	18	49	66	70	85	89	96	56	26	13	592	137	23	455	77
Mafeteng																
12	15	26	59	82	88	104	106	107	66	33	13	711	165	23	546	77
Mohale's Hoek																
14	15	26	62	86	95	113	101	106	61	37	15	731	168	23	563	77
Quthing																
14	17	34	64	83	98	101	93	102	67	37	15	725	184	25	541	75
Mountains																
Mokhotlong																
9	14	23	57	78	90	105	78	66	36	21	9	586	112	19	474	81
Thaba Tseka																
11	14	22	59	67	86	96	72	74	39	27	8	575	121	21	454	79
Qacha's Nek																
13	19	39	66	103	147	163	140	120	46	26	18	900	161	18	739	82

Source: LASA, 1978.

Table II-5. Average monthly temperatures for 10 stations in Lesotho (°C).

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Year
Western lowlands												
Buthe Buthe												
7.3	9.6	13.1	16.2	18.0	19.5	19.8	19.1	17.4	14.6	10.1	6.9	14.3
Leribe												
7.1	9.9	13.7	16.9	18.3	19.8	20.3	19.2	17.8	14.4	10.4	7.3	14.6
Teyateyaneng												
8.0	10.7	13.9	16.9	18.0	20.1	20.3	19.6	17.8	14.7	11.5	8.4	15.0
Maseru												
6.7	10.1	13.3	16.0	18.3	20.5	21.0	20.4	18.3	14.7	10.3	6.7	14.7
Wepener												
7.5	10.5	13.8	17.2	19.1	21.2	22.1	21.3	19.1	14.9	10.9	7.5	15.4
Mafeteng												
7.4	10.3	13.2	16.4	17.6	19.9	20.4	19.5	17.5	14.4	10.9	7.9	14.6
Mohale's Hoek												
8.1	10.7	13.8	16.9	18.8	20.4	21.4	20.2	18.6	14.9	10.9	7.3	15.2
Quthing												
6.9	10.4	13.2	16.1	17.7	19.4	20.5	19.3	17.5	13.9	10.8	7.8	14.5
Eastern mountains												
Mokhotlong												
4.9	9.8	10.9	13.6	14.4	16.3	16.6	16.3	14.4	11.6	7.4	5.0	11.6
Thaba Tseka												
5.6	7.9	11.1	14.0	15.1	17.1	16.9	15.9	14.7	11.8	8.3	5.6	12.0
Qacha's Nek												
7.4	9.8	12.7	14.9	15.9	17.6	18.5	18.0	16.5	13.9	10.6	7.6	13.6

Source: LASA, 1978.

Table II-6. First and last frost dates for Lesotho.

	Elevation (m)	Average last frost	Average first frost	Frost free days between average last and first frost dates
Leribe	1740	14 Sep	10 May	237
Maseru	1530	6 Sep	13 May	254
Mafeteng	1610	20 Sep	19 May	240
Mokhotlong	2200	13 Oct	9 May	187

Source: RSA-WB 1954 (as cited in LASA, 1978).

This does not mean there is actually a water deficit since, except in cases of poor infiltration, most of the precipitation enters the soil and is available for plant use. What it does mean is that the high evaporation rate must be considered in crop management, whether or not the crops are irrigated. If irrigation is used, pan evaporation data as a guide to crop use are very useful to schedule proper amounts and frequency of water application.

d. Further Research Needs

Environmental hazards are widely recognized as an important component of agricultural planning and decision-making in Lesotho (Wilken, 1978b). Recurrent drought (Dyer and Tyson, 1977), frequent hail, killing frosts, and field flooding from too much rain are mentioned by farmers as major problems (Gay, 1977 p. 145-166), as are climate-related hazards such as worms and blight. Farmers' fears are well-placed: crop failures from climate or climate-related causes were reported as 13.7% of total area planted in 1969/70 and 11.5% in 1976/77, the 2 years for which crop failure data is available (BOS, 1972; 1978). Total losses often run into millions of rands. Aside from some tentative investigations into remedial measures such as hail insurance, little has been done either to understand the conditions and probabilities of hazardous events, or to acquaint farmers with methods for reducing risks.

e. Summary

Despite the key role assigned to climate in Lesotho by most agricultural analysts, exact relationships remain largely uninvestigated. Long-term records are available for several major stations, and recent installations of new stations and improvement of existing stations promise that general nationwide reporting will be

Table II-7. Class A pan evaporation[1] for three stations in Lesotho (mm).

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Buthe Buthe												
97	139	181	212	215	145	230	197	178	125	110	84	2013
Maseru												
84	122	186	215	230	260	288	227	174	117	83	62	2048
Mokhotlong												
102	158	193	225	211	211	225	184	176	121	114	100	2020

1. The class A pan uses a standard method and standard equipment to estimate water use by crops as a basis for irrigation scheduling.

Source: LASA, 1978.

considerably improved. However, information on local micro- or meso-scale climates that are vital to farming is lacking. In addition, probabilities of major hazards such as drought, hail, and frosts are not yet available, nor are studies of farmers' perceptions of climate, risk, and risk avoidance strategies. Finally, analagous climates elsewhere in the world could be examined for crops and farming systems that might be considered in Lesotho.

2. Soils

For an agrarian nation, soil is one of the most fundamental resources. Agriculture and the prosperity associated with it depend upon the soil, and the management which maintains and improves the soil, or alternatively, degrades it.

Thus a thorough knowledge of soils and a complete soils inventory are essential to any comprehensive evaluation of agricultural potentials. But although soil conservation has had a long history in Lesotho, scientific soil sampling and analysis were not undertaken until late in the decade under review. For this reason as well as the variability of Lesotho's soils, nationwide evaluations of the soil resource were not possible. This review, therefore, will focus on the 1978 activities as an introduction to the subject.

a. Soil Surveys

Early soil evaluations in Lesotho were mostly subjective-descriptive, of little use to systematic agricultural planning. The excellent reconnaissance surveys and maps of Carroll and Bascomb (1967) and Bawden and Carroll (1968) provided the first nationwide overview. Although certain emphasis and terminologies have since been questioned (Binnie & Partners 1972, V. 3, pp. 19-20), these surveys remain useful for general patterns of soil types. Binnie & Partners (1972, V. 3) elaborate on the earlier Carroll and Bascomb (1967) survey and attempt to reconcile its classifications with more conventional systems.

Soil surveys were conducted by the Conservation Division, Ministry of Agriculture, usually in specific conservation project areas, in some cases associated with area-based agriculture development projects (e.g., Thaba Bosiu). Surveys and accompanying soil maps were either reconnaissance or detailed. Although still far from adequately surveyed, Lesotho no longer is the terra incongnita of earlier times; a great deal is now known about the characteristics and potential of agricultural soils, and forms a basis for sound planning.

b. Summary and Recommendations

Work with with soils has a long history in Lesotho, in part because of their problematic nature and the spectacular erosion to which some are susceptible. Thus, although soil analyses and detailed mapping were still far from complete in 1978, knowledge of soils was much more advanced than in many other countries at comparable stages

of development. There should be no doubt that this work is fundamental to objective agricultural planning and development and there should be no lessening of survey efforts until all farming areas have been mapped in detail.

In a commendable effort to make soil characteristics and potential available to field advisors and farmers, the results of laboratory analyses and field trials were organized in simplified fashion. This effort could be made even more effective by incorporating traditional knowledge Basotho farmers have of soils into classification and evaluation systems. Basotho farmers know soil characteristics, the relationships between different soils and crops, and have developed local classification systems that permit this knowledge to be shared.

3. Water

a. Surface Waters

The Southern African region has four principal watersheds or river systems, the Zambezi and the Limpopo, which flow to the Indian Ocean on the east, and the Orange and Cunene, which flow to the Atlantic Ocean. These four river systems drain 84% of the subcontinent's total area, with the Zambezi basin to the north containing the largest share of the region's water supply (Midgley, 1976). For the interior and western portions of the Republic of South Africa, an area which is largely arid to semi-arid, the principal source of surface water is the Orange river system, which rises in Lesotho. In fact, all major rivers in Southern Africa are international in character, either forming state boundaries or flowing through two or more countries enroute to the sea.

The Southern African interior plateau, known as the highveld, situated to the north and west of Lesotho, is drained to the west by the Vaal river whose tributaries rise along the crest of the Qoatlhamba (Drakensburg escarpment) to the north of Lesotho. The upper Senqu (Orange) river and its tributaries, the Makhaleng and Mohokare (Caledon) rivers, rise within Lesotho and comprise the largest share of the Senqu/Vaal river system discharge.

Measurements of daily, monthly, and annual discharge for Lesotho's principal rivers and tributaries are generally not available prior to the mid-1920s. Accordingly, most estimates of mean annual surface run-off are based on a time series of 50 years or less. Current estimates of the mean annual discharge for the Senqu, Makhaleng, and Mohokare river subbasins, obtained from studies which are representative of several different data series, are compared (Table II-8). Average annual run-off is estimated at approximately 4 billion m^3 (about 3.3 million acre-feet), Although two-thirds of the total flow is attributed to the Senqu main stream, the Makhaleng subbasin has approximately the same water yield per unit area. The Mohokare river watershed, which includes a greater percentage of the lowland area and consequently receives less precipitation, has the

lowest yield of the three principal subbasins. Mean annual water yield for the entire country is 125 mm (about 5 inches) or approximately 15% of total precipitation.

b. Power and Irrigation

Before 1966, Lesotho's water use was limited almost entirely to domestic use and drinking water for animals. While hydroelectric power is not directly agricultural, this potential is, nonetheless, of great interest and indirectly related to agriculture. Two of the main products of most water development projects are power and irrigation (along with flood control, recreation, wildlife, etc.).

It seems that hydroelectric power may have greater potential than irrigation, but irrigation should not be overlooked. The main watersheds that could be used to trap surface water for irrigation are also the watersheds that are the most severely eroded. Along with this constraint is the high sediment level causing costly wear on pumping equipment. In addition, reservoirs are rapidly being filled with sediments, which of course greatly increase costs.

There is no question that there are extensive areas in the lowlands that are irrigable. Estimates range from 20,000-50,000 ha. As the population increases the demand grows for high value crops, e.g., fruits and vegetables, that require intensive and high-cost inputs such as irrigation for consistently high production.

It seems clear that hydroelectric power has great potential and that irrigation may have some significant potential in Lesotho. But in both cases the sediment problem must be mitigated. The

Table II-8. Principle drainage basins and average surface water discharge, Lesotho.

River basin	Drainage area (km^2)	Mean annual runoff (m^3/s)	Annual discharge/km^2 (1000 m^3)
Senqu above Makaleng	20,714	97.1	148.4
Makhaleng	3,044	14.2	147.1
Mohokare	6,694	27.5	118.9
Other catchments[1]	260	.6	72.8
Totals	30,712	137.1	140.8

1. Includes several small tributaries situated between the Mohokare and Makhaleng Rivers in the west-central border area.

Source: SWECO, 1977 (as cited in LASA, 1978).

current--1986--hydroelectric planning recognizes this problem, but solutions will be difficult.

C. Human Resources

While physical resources are essential to development, human resources are priceless and indispensable. Human resources--people--cannot be separated from any part of the agricultural sector, and thus people are an integral part of this report. Three areas are discussed: population, education, and nutrition.

1. Population

According to the 1976 census, Lesotho had a population of 1.2 million, with an average annual growth rate of 2.27%. At this rate, it is likely the population at the beginning of FSRP, July 1979, was near 1.3 million and at the end of the project, July 1986, the population would be approaching 1.5 million. The 2.27% growth rate has a doubling time of 31 years (Table II-9).

As is typical of countries with a rapid growth rate, a high proportion of the population is very young. Approximately 40% of Lesotho's population is under 15 years of age (Table II-10).

In 1976 roughly half the population lived in the lowlands, where the percent increase was greater. However, there is a substantial increase in the other regions including the mountains (Table II-11). Much of the migration to the lowlands was to Maseru. The population of the national capital increased by 80% between 1966 and 1976.

Table II-9. Population and population growth rate.

Characteristic	1976 Lesotho census data
Population	1,216,833
Males	586,870
Females	629,963
Population growth rate	2.27
Years required to double population	31
Estimated population in year 2000	1,713,792

Source: Jilbert, 1978 (as cited in LASA, 1978).

2. Education

Lesotho's educational system is patterned after that of the Western world. Schools were first established by French Evangelical missionaries in 1834. These and other church schools continued largely independent of government control until the first 5-year plan in 1970, at which time the government began to have more control.

Table II-10. Percentage distribution of the population by age and sex.

Age	Males	Females
0- 4	15.54	15.10
5- 9	13.05	12.74
10-14	11.41	11.16
15-19	10.04	9.83
20-24	8.75	8.60
25-29	7.59	7.49
30-34	6.58	6.51
35-39	5.69	5.67
40-44	4.89	4.91
45-49	4.15	4.21
50-54	3.47	3.58
55-59	2.83	2.98
60-64	2.22	2.43
65 & over	3.79	4.79

Source: LASA, 1978.

Table II-11. Regional population distribution, Lesotho.

Region	Total population 1976	%	Change: 1966-1976 Total	%
Lowlands	661,300	54.3	+156,546	+31.0
Foothills	151,819	12.5	+ 23,626	+18.4
Mountains	75,505	6.2	+ 8,002	+11.9
Mountain valleys	236,663	19.4	+ 40,880	+20.9
Senqu (Orange) valley	91,537	7.5	+ 15,445	+20.3
Totals	1,216,824		244,499	

Source: Jilbert, 1978 (as cited in LASA, 1978).

The objectives of the second 5-year plan were:

- To improve the quality and efficiency of primary education.
- To continue to develop secondary education with emphasis in math, science, and practical studies.
- To develop technical, vocational, and higher education to meet national manpower needs.
- To initiate a coordinated program of nonformal education.
- To strengthen government control and supervision of educational activities.

The literacy rate in Lesotho was approximately 60%, 66% in the lowlands and 54% in the highlands. The rate for women was 64%. A factor contributing to lower literacy among men (46%) is that boys are needed as herdboys, especially in the mountain region where there is more livestock and grazing.

Total school enrollment by class, (Table II-12), uses the "graduating class" of 1977, which began grade 1 in 1966. The data show high dropout rates after the first year, after completing primary, and after completing the lower secondary. The dropout rate, including those who did not pass the final exam, is alarming. It is discouraging that only 354 passed the final exam of the 46,598 who started the first class.

Table II-12. Student enrollment for a class beginning the first grade in 1966 and "graduating" in 1977.

Year	Number of students	Year	Number of students
Primary		Secondary lower	
1966	46,598	1973	4,355
1967	30,159	1974	4,004
1968	29,430	1975	3,553
1969	23,426	Secondary upper	
1970	22,298	1976	1,316
1971	17,384	1977	1,234
1972	12,197	Passing Final	354

Sources: BOS, 1977 (as cited in LASA, 1978).

The student/teacher ratio in the primary grades was high, 1:50, but was substantially better in the secondary grades, 1:25. There was a serious shortage of qualified teachers which the government was attempting to correct in the second 5-year plan (1975-1980).

3. Nutrition

Although poverty was visibly prevalent in Lesotho, there was little or no indication of starvation or famine. This can be very misleading in terms of nutrition, since poor nutrition is not always visible. The second 5-year plan emphasized the need to improve human nutrition. Examples of policy questions that would affect agriculture are:

- the nutritional implications of subsistence versus commercial production;
- decreased dependency on South Africa, either through import substitution or consumption reduction;
- local manufacure of food products, especially those that contribute most directly to improved nutrition (e.g., weaning and children foods);
- food aid as a direct measure against undernourishment verus the disincentives it brings to domestic production;
- emphasis of nutritional efforts, whether nationwide or focused on identified at-risk groups; and
- positive and negative impacts of establishing food standards legislation.

Special attention was directed at certain "at-risk groups" who are the first to experience hunger or malnutrition: children under the age of five, expectant mothers, and families of crippled miners:

- Children: 20% of under-fives were chronically malnourished and below their full growth potential (11% in Maseru, 25% in the mountains) (UCLA, 1976).
- Mothers: 5% were undernourished (but 21% are obese). 5% were suffering from goitre (was 15% in 1976) (UCLA, 1976).
- Families: 33% of all families probably experienced a shortfall in their basic energy requirement (in 1976 they received a monthly income in cash and in-kind of less than R40 per month for a 4.3 member household) (UC-NUL).

The daily diet of much of the population was a bowl of stiff maize porridge (papa) and a meat/legume relish or green vegetable relish (moroho). Whether or not this diet is adequate is open to question but one thing is certain--there is not much variety in such a

diet. Table II-13 compares estimated average diet with a recommended diet in Lesotho. Changes in agricultural production would be necessary to provide food self-sufficiency in Lesotho and a recommended diet for its citizens (Table II-14).

D. Employment and Migration

Employment of migrant Basotho workers in RSA has an important effect on Lesotho's agriculture, because these men are not available, or available only for short periods, to do farm labor (Tables II-15 and II-16).

Table II-13. Daily per capita food consumption estimates (per capita grams per day).

Food commodities	Estimated average diet	Recommended diet
Body builders		
Milk	50	80
Eggs	3	15
Meat/fish	20	30
Beans/peas	2	30
Disease preventers		
Vegetables	90	120
Fruits	10	30
Energy producers		
Maize	270	180
Sorghum	50	60
Wheat	150	100
Potatoes, etc.	30	30
Sugar	40	30
Oil/fat	4	10
Luxury foods	25	10
Flavorings		
Tea	1	3
Salt	6	5

Sources: Gay and Guma, 1978, BOS, 1973 (as cited in LASA, 1978).

Table II-14. Target productions of food commodities for agricultural self-sufficiency (units are t, except eggs).

Food commodity	Target production for self-sufficiency 1975-1976	Provisional estimates of actual production	Deficiency (-) (+) Surplus
Milk	35,040	27,000	-8,040
Eggs (dozen)	9,125,000	1,258,000	-7,867,000
Meat/fish	13,140	8,722	-4,418
Beans/peas	13,140	14,413	+1,273
Fruit & vegetables	65,700	7,700	-58,000
Maize	84,840	49,128	-35,712
Sorghum	26,280	24,540	-1,740
Wheat	45,800	44,640	-1,160
Potatoes & rice	6,570	4,960	-1,610

Notes: 1. In addition, the following items would have been needed as imports: 13,140 t sugar, 4,380 t oil, 1,315 t tea, 2,190 t salt. 2. The items in shortest supply were eggs, fruits, and vegetables, and maize. The most urgently needed items in the event of a blockade: beans, vegetables, maize, and fortified margarine).

Source: LASA, 1978.

Table II-15. Estimated working age Basotho and their involvement in employment (1976).

	Males		Females		Both Sexes
	15-24	25-64	15-24	25-64	15-64
1976 population (%)	18.8	37.4	18.4	37.8	56.2
Numbers ('000)	110.3	219.6	116.1	238.0	684.0
Participation rate (%)	68	94	58	86	81
Engaged in employment ('000)	75	206	67	205	553
Subtotals by sex					
Numbers ('000)	329.9		354.1		
Employed ('000)	281		272		

Source: LASA, 1978.

Studies of the migrant labor issue indicated:

- Migration to the Republic removed 54% of Lesotho's male labor force, which is 63% of those actually employed. This rate was believed to be the highest in the world.
- The positive view is that these same men each earned a cash wage of R875/yr or higher (26 shifts/mo at a minimum wage).
- Female migration was inconsequential compared to male migration, although it was undoubtedly significant to the households concerned.
- Females had a much higher unemployment rate.
- After allowing for migration, Lesotho's residual domestic mix of employed persons was 71% female. This fact was not taken into account by development programs, the extension service, and other institutions.
- Lesotho's "unemployment problem" (those persons without work but who are of working age) was 63% female.

The black population in South Africa in 1978 was more than 15 million and growing at more than 3% per year. Unemployment was high. There is reason to believe the South Africa government may have wanted

Table II-16. Employment of Basotho aged 15-64, by sector, 1975 (thousands of people).

Internal employment	
Manufacturing	2.0
Construction and civil engineering	2.5
Government	9.2
Tourism	0.5
Other Services	13.3
Subtotal, Modern sector	27.5
Handicrafts and informal activities	20.1
Agriculture	304.4
Subtotal, traditional sector	324.5
Subtotal, internal employment	352.0
External (migration employment)	188.0
Grand total, internal and external	540.0

Source: LASA, 1978.

to see its own black population employed and to decrease the use of imported labor. Many observers felt, because of the magnitude of migrant labor, there was not sufficient labor to efficiently operate farms in Lesotho. Others argued that there were alternative explanations for low production and fallow lands. In any case it seemed reasonable that the two phenomena, the size of the migrant labor force and declining production, were related in some way.

E. Land Tenure

All quotes in this section are from LASA, 1978.

1. General Concepts

Moshoeshoe I once wrote:

> "I could not, according to the custom of my tribe, alienate any portion of my Territory without the consent of the people ... The people I govern look upon me as being entrusted with the preservation of their country and I would not forfeit or cede my right to any part of it without being considered as having robbed the community."

The land tenure system in Lesotho is very unusual and is intriguing, to say the least. It is quite complex and yet, in some respects, it can be stated rather simply:

> "No Mosotho can own land outright. In Basotho eyes, all land and associated rights of use are vested solely in the office of the Paramount Chief (now King) as its guardian and trustee on behalf of the nation."

The above statement may indicate communal tenure. The quote continues:

> "However, no Mosotho can claim rights to land or its use simply because of its existence or citizenship. Rights are associated with adulthood, allegiance and physical presence, and receipt of over entitlement is constrained by land scarcity."
> "The fundamental principle is that the land belongs to the nation", i.e., "the Basotho people."

2. Usufruct Rights

Of special interest to the agriculture sector is the collection of usufruct rights. Briefly stated, "No Mosotho owns land but upon satisfying certain criteria every adult male may expect to be allocated rights to the produce of land."

3. Residential Rights

"The right to residential land is the primary right within Lesotho's land tenure. Without a residence there can be no claim to other land rights."

4. Use Rights to Arable Land

"Every entitled Mosotho has a right to three "lands" (arable fields)...

"A young man will apply for his residence site shortly before or at the time of his marriage. Once this is allocated he applies for lands ... One field will usually be allocated as soon as possible ... In the course of time, he can probably expect a second field. A third field ... if received, will ... be several years after marriage."

" ... private rights to the produce of arable lands lapse at the end of the growing season. Public grazing rights prevail in winter for whatever stover crop residue, weeds and grasses are on the field."

Land can be taken away if left uncultivated for two or more years or from individuals who have more than their subsistence needs.

5. Grazing Rights

"Rights to grazing resources differ from those of arable land in that land is grazed in common by all the individuals so entitled. While there are individual cultivation rights, there are no individual grazing rights."

Grazing rights may be divided into open grazing and reserved grazing. "In open grazing ... cattle are mainly turned loose in an area and allowed to graze at will. Reserved grazing is found where alternate or specified uses of the range are recognized and control of livestock is necessary to prevent resource damage or conflict."

"A man acquires grazing rights by means of acquiring stock. There are no limits ... in terms of the number of stock a man may own ... Large herds are therefore built up by individuals, and by the nation as a whole with serious consequences for the commonly shared grazing resource."

6. Population Growth and Land Distribution

Table II-17 shows the effects of population growth on arable land resources. Perhaps of most interest are the reductions in acres per field, fields and acres per household, per capita acreage, and the increase in population per household.

Space does not permit inclusion of the many implications and ramifications of Lesotho's land tenure system. The reader is referred to LASA, 1978 (Ch. V) for more detail.

F. Cropping Systems

1. Production

Of the R18 million estimated value for all crops, the field crops

(all grains) accounted for R11 million. Somewhat less than half the R11 million was attributed to wheat, beans, and peas, the only export crops (Table II-18). An interesting and surprising point is that the estimated value of peaches was greater than that of any other crop, including maize. Early missionaries in Lesotho distributed peach trees and many still produce fruit, mostly for home use. The total estimated value for vegetable crops was small, but these crops may have more potential in the future, especially potatoes and cabbage if they are irrigated.

The data indicate per hectare yields were low. Yields below 1,000 kg/ha for any of the grain crops tested would normally be considered marginal at best. Total production levels are also low. Some data (not shown) indicate that since 1934 maize production has increased slightly, wheat and sorghum production have nearly doubled, and bean and pea production have remained essentially the same. "At present grain yields of less than 1000 kg/ha, Lesotho has a production deficit of approximately 40% of annual consumption need (LASA, 1978)."

2. Land Use and Production

The 1976 cropping mix in each region is shown in Table II-19. Maize had the largest hectarage in all except the mountain region, where wheat was the leading crop. Sorghum was important in all except the mountain region. In the entire country the order of importance was maize, wheat, sorghum, beans and peas.

Two points should be noted from these data: the hectarage of the lowlands was roughly half the total for the country, and the percent fallow, for reasons not known, varied greatly over time. The 32%

Table II-17. Effect of population growth on arable land resources per household and per capita for three census years

	1949-50	1960-61	1969-70
No. of farming households	149,800	158,172	185,309
No. of fields	389,600	388,657	402,220
No. of arable acres held	930,000	871,687	909,788
Acres per field	2.39	2.24	2.26
Fields/farming household	2.60	2.46	2.17
Acres/farming household	6.21	5.51	4.91
Population/household	3.60	4.09	4.48
Per capita acreage (average)	1.72	1.35	1.10

Source: LASA, 1978.

fallow in 1976 obviously had a great effect on total production. "The recent trend for increased fallow is believed to be related to improved wages for mine labor (LASA, 1978)."

Summer crops are planted in Lesotho during September to December, depending upon the availability of spring moisture to facilitate plowing and seedbed preparation. The plowing season begins following the first heavy spring rain. Most draft operations are performed by ox teams, although an estimated 800 tractors are also employed at this time of year. Winter crops are typically planted in the fall (April

Table II-18. Estimated annual production and gross value for the crop subsector excluding processing (in 1978 Rand).

Subsector	Area (ha)	Yield (kg/ha)	Farm price (R/ha)	Gross value (R)
Field crops				
Maize	80,336	630	.072	3,644,040
Sorghum	42,485	690	.079	2,315,857
Wheat	41,686	580	.108	2,610,585
Beans	19,649	310	.290	1,766,445
Peas	9,410	450	.230	973,935
Barley-oats	1,531	590	.095	85,813
Subtotal	195,565			R11,396,675
Fruit crops	('000 trees)	(kg/tree)		
Peaches	1,000	9	.45	4,050,000
Apricots	60	7	.42	176,400
Apples & others	45	8	.40	144,000
Subtotal	1,105 (trees)			R 4,370,400
Forage crops	226	5 (tons)	.07	79,100
Vegetable crops				
Potatoes	90	12,000	.12	129,600
Cabbage	40	10,000	.35	140,000
Asparagus	90	800	.20	14,400
Home gardens ('000)	130 (plots)	--- R15/plot----		1,950,000
Subtotal	220+			R 2,233,000
Forestry crops	886	N.A.	N.A.	N.A.
Total subsector	196,897+			R18,079,175

Source: LASA, 1978.

through June) and harvested during the following spring to early summer. The main winter crops are wheat and peas, roughly 10% of annual crop hectarage. The main harvest season in Lesotho occurs after the summer rains subside, and usually extends into mid-winter (June and July). A calendar of operations for typical crop production practices is summarized in Table II-20.

3. Seasonal Labor Demand

"Crop production activites in Lesotho consume more labor hours than all other productive activities combined. Because significant numbers of men and women of working age are employed outside the country for most of the year, the possibility of seasonal labor shortages in the crops sector is a question that needs careful examination (LASA, 1978)."

Space does not permit adequate treatment of this subject. There was a very high demand for labor during November, December, March, April, and July. Animal labor input requirements for the main crops are shown in Table II-21. For further discussion the reader is referred to LASA, 1978 (Ch. VI).

Table II-19. Cropping mix in Lesotho's principle ecological zones.

Crop	Lowlands	Foothills	Mountains	Orange River valley	Lesotho
	Percent of annual regional totals				
Maize	41.17	42.27	27.31	45.97	37.75
Sorghum	23.20	26.22	5.72	34.94	19.69
Wheat	14.39	13.15	52.57	10.32	24.86
Beans	19.34	16.33	3.40	7.51	13.20
Peas	1.90	2.03	10.94	1.44	4.50
Total	100.00	100.00	100.00	100.00	100.00
	Total hectares ('000)				
	115.6	68.3	56.1	21.4	261.5
	Percent fallow				
	29.4	30.0	14.9	23.0	32.3

Adapted from: BOS, 1973: Morojele, 1963; as cited in LASA, 1978.

Table II-20. Calendar of operations for typical crop production practices in Lesotho.

Production operations	Timing and duration											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Summer Crops:												
Maize												
Land preparation	xxxxxxxxxxxx											xxx
Plant		xxxxxxxxxxxx										
Cultivate & Weed		xxxxxxxxxxxxxxxxxxxx										
Harvest								xxxxxxxxxxxxxxxx				
Sorghum												
Land preparation	xxxxxxxxxxx										xxxxxxxx	
Plant	xxxxxxxxxxxxxxxx											
Cultivate & Weed		xxxxxxxxxxxxxxxxxxxx										
Harvest								xxxxxxxxxxxxxx				
Beans												
Land preparation	xxxxxxxxxxx											xxx
Plant		xxxxxxxxxxxxx										
Cultivate & Weed			xxxxxxxxxxxxxxxxxx									
Harvest						xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx						
Wheat												
Land preparation	xxxxxxxxxxxxxxxxxx											
Plant		xxxxxxxxxxxxx										
Harvest					xxxxxxxxxxxxxxxxxxx							
Peas												
Land preparation		xxxxxxxx										
Plant		xxxxxxxx										
Harvest								xxxxxxxx				
Winter Crops												
Wheat												
Land Preparation							xxxxxxxxxxxxx					
Plant							xxxxxxxxxxxxxxxxxxxxxx					
Harvest		xxxxxxxxxxxxx										
Peas												
Land preparation										xxxxxxx		
Plant										xxxxxxx		
Harvest			xxxxxxxx									

Source: LASA, 1978.

4. Growth Potential and Constraints (all quotes from LASA, 1978)

"Potential exists in nearly all aspects of food production, marketing and consumption for significant improvement in a relatively short period of time ... similar observations have been made very many times over the past 40 years."

The main reasons given for poor performance were:

- A risky natural environment,
- External employment opportunities,
- The system of land tenure, and
- Lack of infrastructure, i.e., markets and transportation.

"Crop yields on the west side of the Caledon River in the Orange Free State rank among the highest in the world for a rainfed agriculture; only the production practices and management systems differ."

The following statement, made in 1978, has great significance: "Technology is available to farmers in Lesotho at the present time to significantly improve production levels of basic food crops, but extension services and communication links are practically absent in most parts of the country. Rural people simply do not have the opportunity they need to work with skilled people, and for the most part exension services are a new experience for Lesotho and could be more creatively pursued."

5. Recent Production Data

More recent data are available on the production of crops beyond 1979. Figure II-1 shows 10-year trends for hectares planted for the five major crops. Although there are slight trends, e.g., a slight

Table II-21. Annual labor requirements (man-days/ha) by type of operation for current crop production practices in Lesotho (provisional estimates).

	Traction operations			Hand operations		
Crop	Land preparation	Planting	Cultivating	Weeding	Harvesting	Total
Maize	4.2	1.5	1.2	8.5	17.5	32.9
Sorghum	4.2	1.5	1.2	8.5	13.6	29.0
Wheat	4.2	1.5			11.8	17.5
Beans	4.2	1.5	1.2	8.5	21.4	36.8
Peas	4.2	1.5			12.4	18.1

Source: LASA, 1978.

increase for maize, a decrease for wheat, and a slight decrease for beans, the lines are, in general, surprisingly near horizontal (LASR, 1985). When 10-year average yield data are compared for farm crops in Lesotho, Orange Free State, and RSA, yields are substantially lower in Lesotho (Table II-22).

Yield and total production data over the 10-year period 1974-84 for the five major grain crops in Lesotho are shown in Tables II-23 and II-24. The tables, along with Figure II-1, appear to indicate the following:

- The main factor in total production variability is yield per hectare rather than hectares planted. Thus, there appears to be a fair relationship between yield and total production figures.

- Yields for maize and sorghum were low in 1974-76 and also in 1981-84, but yields were somewhat higher during the intervening years--1976-81.

- Wheat and bean yields also increased during 1976-81, but subsequent yields were very low.

- There appeared to be a downward trend in pea yield during the 10-year period. The data in Table II-23 and II-24 do not support the statement in LASR, 1985, p. 19, "All five major crops in Lesotho have shown a decline in production since the mid-1970s." The increases during 1976-79 are indicative of neither a long-term increase or decrease in yield or production.

- It is reasonable to assume the yield and production increase during 1976-79 was due to favorable environmental conditions. However, a comparison of data in Tables II-23 and II-24 with II-25 does not show a clear relationship between rainfall and yield/production. One is left wondering what are the factors involved.

Table II-22. Comparison of yields (kg/ha), 10-year average ending 1983/84.

Crop	Lesotho	OFS	RSA
Maize	785	1208	2001
Sorghum	803	--	1937
Wheat	843	1281	1078
Beans	477	--	1123

Source: LASR, 1985.

G. Livestock Systems

Livestock are an important cultural element which have important implications for production and economic development. Cattle provide draft power, food, raw materials for clothing, and marketable assets for each if needed. "Cattle are the most prestigious of all domesticated animals. They are prominent in weddings, funerals, and religious events. Sheep and goats are largely valued ... for their market value in wool and mohair..." Horses and donkeys are important because of poor roads (LASA, 1978 p. VII-1).

1. Production and Income

In roughly 9 years out of 10, the livestock sector makes the largest contribution to the GDP. In addition, it accounts for 60-70% of the national export revenues. "In relation to crop production, livestock husbandry appears to be less risky, requires less operating capital, and in most instances offers a long term payoff in ... net return to family labor (Table II-26). Table II-27 reports the population of six types of animals from 1935 to 1976.

Table II-23. Yields of the major grain crops in Lesotho over a 10-year period, (kg/ha planted).

	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84
Maize	556	425	1359	1284	1021	892	774	608	601	573
Sorghum	547	442	1331	1382	1274	918	748	446	539	540
Wheat	714	748	1396	1269	885	919	721	536	465	511
Beans	436	246	1207	755	699	438	385	294	255	116
Peas	400	438	724	725	1034	687	652	432	298	411

Adapted from LASR, 1985.

Table II-24. Total production of the major grain crops in Lesotho over a 10-year period ('000 t).

	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84
Maize	70	49	126	143	125	106	106	83	76	79
Sorghum	37	25	62	86	69	59	48	26	31	34
Wheat	45	45	61	58	33	28	17	14	15	17
Beans	13	9	21	11	8	4	4	5	2	1
Peas	6	6	7	4	7	5	3	5	3	4

Adapted from LASR, 1985.

Usually the numbers were lowest in 1935 or 1937, gradually increased to 1970 or 1973 and decreased slightly by 1976.

The LSGU (large stock grazing unit), provides the most realistic basis for evaluation of livestock numbers in terms of grazing. There does not appear to be a trend upward or downward until the increase during 1970 and 1973 (trend data not shown). This is of interest when considering the national population approximately doubled during the same period, beginning in 1936. This does not fit with the notion that grazing pressure increases with increase in population. There is no apparent relationship between increase in population and increase in livestock numbers in this instance.

2. The Range Resource

"The highveld and mountain pasture grasslands are one of Lesotho's greatest natural resources." The previous section indicates no appreciable increase in grazing pressure in the 40 years before 1970. Presumably this means no increase in erosion induced by overgrazing. "Reports by missionaries as early as 1868 document many of the same conditions that can be observed today, namely, severe sheet and gully erosion ..." Overgrazing may have been a problem for more than a century (LASA, 1978).

Table II-25. Winter and summer precipitation (mm) over a 10-year period, 1974-84, at four locations in Lesotho.

	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84
Maseru										
Summer	709	793	666	621	538	424	613	599	372	671
Winter	163	246	165	194	223	118	140	162	128	209
Total	872	1039	831	815	761	542	753	761	500	880
Nyakosoba										
Summer	772	827	748	746	nd[1]	431	nd	576	nd	nd
Winter	191	225	189	223	nd	136	nd	319	nd	nd
Total	963	1082	937	919	nd	567	nd	895	nd	nd
Siloe										
Summer	525	848	698	605	420	456	nd	456	nd	nd
Winter	163	208	182	189	218	131	nd	121	230	nd
Total	688	1051	880	794	638	587	nd	577	nd	nd
Molumong										
Summer	645	709	636	513	nd	505	512	505	nd	536
Winter	204	181	101	221	nd	107	215	107	nd	nd
Total	843	890	737	734	nd	612	727	612	nd	nd

1. No data.

Source: FSRP weather data.

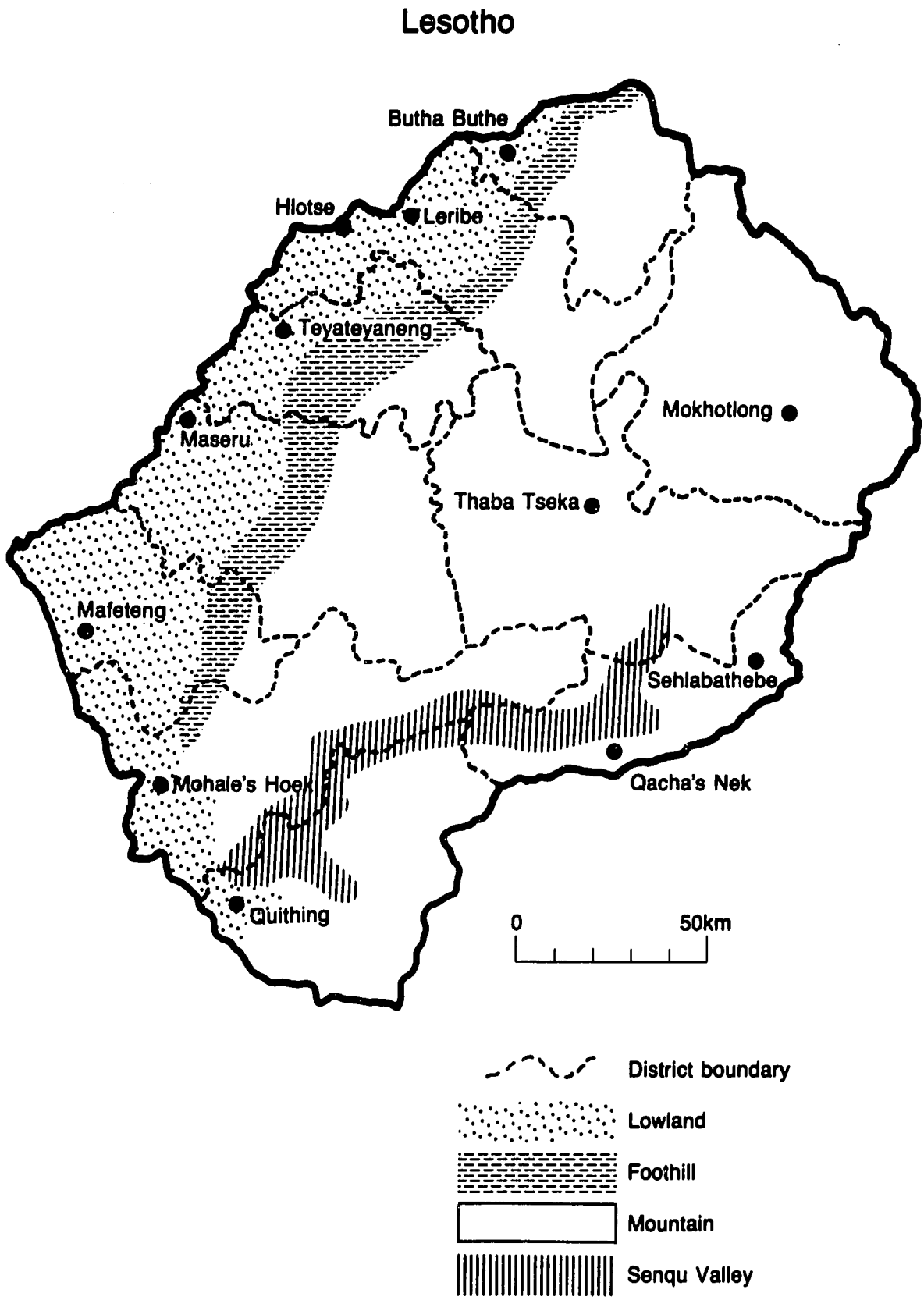

Figure II-1. The four physiographic regions of Lesotho.

Table II-26. Some market value equivalent figures for livestock products.

	Market value equivalent (million Rands)		Market value equivalent (million Rands)
Fresh meat		Live exports	
Beef	3.45	Cattle	1.66
Mutton	1.04	Other: sheep, goats, horses, donkeys	0.48
Other: goat, pork, poultry, offals, fish	2.15	Total live exports	2.14
Total fresh meat	6.64		
Animal products		Draft power	
Milk	5.08	Oxen	1.69
Eggs	0.79	Horses	0.99
Wool	4.74	Other: donkeys & mules	0.60
Mohair	3.74	Total draft power	2.30
Other: hides & skins	0.64		
Total animal products	14.99	Total gross revenues	27.05

Source: Adpated from LASA, 1978.

Table II-27. Livestock inventories, 1935-1976.

Animal	Range ('000)
Sheep	1286-1661
Goats	712-974
Cattle	352-552
Horses	80-114
Mules	1-4
Donkeys	18-88
Large stock grazing units[1]	691-1091

1. The Large Stock Grazing Units assigns value to each animal type: cattle, 0.8; horses, 0.7; mules, 0.6; donkeys, 0.5; and sheep and goats, 0.2.

Source: CPDO, n.d., as cited in LASA, 1978.

"Recommended annual stocking rates for the non-arable area range from ... 4 to 6.5 ha/GU" which would allow for 390,000 to 630,000 GU--distinctly below the actual GUs between 1935 and 1970 and substantially below the one million of 1970 and 1973.

The above provide an overview of the total grazing area. No doubt attention should be given to specific areas and to times during the season. "Grass growth begins normally in October at the lower elevations and nearly all non-draft animals have been moved up into the foothills by late October. By late December or early January, the upper reaches are being grazed and usually by May most of the livestock have been returned to the Foothill areas where, depending upon the severity of the winter, many will stay throughout the months of June to September" (Table II-28) (LASA, 1978).

3. Wool and Mohair

"The natural environment of Lesotho is conducive to the production of very fine long staple wool and mohair. Merino sheep and Angora goats were introduced nearly 100 years ago" and soon became a thriving industry. But the industry was plagued by "boom and bust" cycles and the Basotho were not accustomed to storing the products.

"In 1929 the Basotho Long Blue Mohair (BFM) ... accounted for 50% of the nation's GDP and was recognized throughout the world for its outstanding quality. Since 1950 there has been a sharp decline in quality. The BFM grade dropped to 3% in 1976. "This ... reduction in quality, coupled with low yield per annum has meant that Lesotho has not been able to take advantage of a vastly improved international market since the 1950's." Workers believe the quality, and income, could be restored with few changes (LASA, 1978).

4. Poultry

"Considerable improvements have been made in the poultry industry since independence. Flocks have been upgraded with commercial type

Table II-28. Distribution of animal grazing units.

Region	Grazing units	
	Total	Per capita
Lowland	278,486	.72
Foothill	224,600	.77
Mountain	587,340	2.78
Senqu River	92,740	.90
Total	1,183,160	1.04

Source: LASA, 1978.

breeds for egg production and a broiler industry is becoming established to compete with the import of fresh meat from the Republic. The majority of flocks remain small and are widely held (LASA, 1978)".

5. Draft Power

" ... the fact that the vast majority of farming operations still rely on animal power has clearly been neglected in development efforts ... The potential benefits of simple improvements in such things as pulling yokes, work rations, and animal implements apparently far exceed the cost ..." (LASA, 1978).

H. Conservation

1. Soil Erosion

> The second 5-year Development Plan (1975-80) for Lesotho states: "Topsoil and water are two of Lesotho's most valuable resources. Both are being wasted in a spectacular process of erosion. This erosion has been going on for more than a generation despite the installation of a basic protection system of contour banks on virtually all arable land. The surge of water down inadequately vegetated slopes is obviously destroying topsoil by gully formation, particularly in the lowlands. But the widespread sheet erosion which accompanies such surges, although much less visible, is far more deleterious because it results in general reduction of fertility on both range land and cultivated land. The conservation of soil and water is particularly difficult in Lesotho because of physical factors which cannot be changed: rugged topography, intense summer rain storms, cold winters, and, in the lowland, highly dispersible soils. However, the national potential for erosion is aggravated by forms of poor land use which can be changed, especially overgrazing, poor cropping, and cultivating of unsuitable steep land or of land without adequate protection (LASA, 1978)."

One wonders how many agricultural workers having come into Lesotho and, after seeing the dongas, have exclaimed: "Why don't they do something?" The fact is "they" have been doing something for at least 45 years. It is of interest that efforts at conservation of soil and water began in Lesotho and in the United States at about the same time--the early 1930s. The soil erosion/conservation issue is discussed at some length in Section III-D (Soils).

2. Early Conservation Programs

Erosion has been a serious problem for possibly up to a century or more. Stockley (1947; as cited in LASA, 1978). reports "on ... the condition of the landscape in 1908 ...":

> "Recent and superficial deposits cover the low grounds and consist of stratified clay, sands, and gravels ... The rivers in

the course of ages have cut their way through them, and as they are loose and easily removed, the amount swept away by every storm is considerable ... The destruction of the wood and bush of the country, together with the increase of cattle that eat off the grass, has powerfully assisted the formation of dongas. They not only reduce the area of arable land, but also drain off the water and disfigure the country. If nothing is done to check their formation, they will render the water problem a very serious one at no distant future."

Efforts began about 1935 as an outgrowth of the Pim report (Pim, 1935), with an inventory of soil resources via the soil survey. "Based upon reconnaissance surveys, the Pim Report recommended specific conservation measures including certain lands, buffer strips, grassed meadows, dam building and tree planting, plus small works for controlled irrigation from small streams.

"These recommendations resulted in what was, and still is, the most intensive soil conservation effort ever launched in Lesotho, and one of the most notable in all southern Africa. Over the next 20 years the concepts of contour banks and contour ploughing were extended over thousands of hectares to the remotest parts of farm regions. By 1952, the Basutoland Department of Agriculture could report that approximately two-thirds of the arable acreage in the lowlands had been protected by terraces and grass stips, about three-fourths of the Foothills had been protected with grass on buffer strips, and that the whole Mountain Region should be completely protected by the next year (1953). The basic recommendations of the Pim Report ... were substantially implemented by the mid-1950's.

"Several other characteristics of the Pim Report merit attention:

a) the Report argued for changes in the land tenure system to give the farmers greater identification with the land and thus greater inducement to make long-term investments in erosion-control measures.

b) soil erosion in Lesotho was depicted at near-disaster levels, and arresting erosion was granted first priority without reference to other national needs.

c) strong emphasis was placed upon tree planting for erosion control.

d) provision for maintenance of conservation structures (e.g., terraces) is meagre or non-existant.

e) nowhere are claims of the seriousness of erosion, supported by quantitative estimates of rates of erosion, nor are arguments for conservation programs supported by estimates of actual benefits to be gained." (LASA, 1978).

3. Recent Conservation Programs

Beginning in 1966, a number of donor-sponsored conservation projects were initiated.

Leribe/Khomakhoana Projects

"The Leribe Project had extensive conservation objectives, including work plans, structures, conservation practices, surveys and research programs." The Khomokhoana Project which followed, "included provisions for implementing the watershed plans developed in the Leribe Pilot Project and for improving and conserving soil through practices of conservation farming methods embracing both crops and livestock...

"Technically the Projects were relatively well-designed, but lack of support and cooperation has hampered effective implementation ..."

Senqu River Agicultural Extension Project (UNDP)

The project encompassed two southern districts, Mohale's Hoek and Quthing. The area involved was 6,470 km^2, or about 20% of the entire country. The specific objectives were to apply "sound crop production and conservation practices" and "expand conservation works and practices in support of production and protection."

"Achievment ... suffered from lack of equipment, insufficient qualified ... personnel, and failure of coordination."

Thaba Basiu Rural Development Project (IBRD-IDA)

The objective here was the "improvement of the livelihood of 17,500 farm families in a 120,000 hectare area comprising most of the Little Caledon River Watershed and the Berea Plateau."

The conservation component was designed to treat 16,000 ha with diversion terraces, drainage structures, repairs to older terraces, access roads, plus fencing, grass, and tree planting.

The goals may have been unrealistic. " ... the final evaluation should stress the continued reliance on expensive structural approaches to conservation."

Land and Water Resource Development Project (LWRD)

This Project, initiated in 1975, is an 8-year "institutional and technical manpower development effort addressed previously to Lesotho's soil erosion problem."

"The two primary project purposes are to promote incorporation of land and water use plans in all agricultural development projects and to assist Lesotho farmers to adopt proper land use management practices."

"The goals and objectives of LWRD are difficult to fault, as is the effective organization the Conservation Division has developed in the last few years ... There is some evidence the Division focuses too heavily upon capital-intensive, high cost structural approaches to conservation" (LASA, 1978).

4. Conclusions

"Several points emerge from this brief review of past and present conservation efforts in Lesotho:

"1. Conservation programs are heavily influenced by policies formulated in other subsectors and sectors. For example, the goal of self-sufficiency in food which has its origins outside the agricultural sector gives considerable direction to conservation efforts. It is not apparent how the realities faced by Conservation Division are fed back into the decision- and policy-making processes.

"2. The necessity for popular support for conservation projects and practices has been recongnized for many years. Educational efforts, particularly in project areas, have been partially successful in creating an awareness of erosion hazards. However, the design of structures and practices that are within the labor and economic range of villages has not progressed as far.

"3. Maintenance of conservation structures and continuation of conservation practices are as important as original installation. Appraisal of post-project maintenance and continuation of conservation proposals. As a corollary, it appears that more research on land treatments and managements methods within the capability of villages could prove fruitful.

"4. Considerable progress has been made in surveying and analyzing the soils of Lesotho. However, the data base is far from complete. Soils, erosion, and hydrologic surveys are needed to identify the actual risk potential and thus the conservation needs of Lesotho. Area-based projects especially should pay more attention to environmental parameters that they have in the past to avoid setting unrealistic goals.

"5. Although conservation is not necessarily amenable to strict benefit/cost analyses (see point 1), it still can be subjected to a variety of analytical processes (e.g., cost-effectiveness) to determine the most efficient method of achieving conservation objectives. For agricultural planners it is necessary to place conservation within the context of national goals and objectives. Alternative approaches merit consideration both from cost-effectiveness point of view, and also as they might prove amenable to village identification, participation, and continuation" (LASA, 1978).

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A. Administration

1. Introduction

Prior to 1979, research in Lesotho was conducted by the Agricultural Experiment Station, a part of the Crop Production Division of the Ministry of Agriculture, and donor-operated projects. Some MOA divisions carried out specific studies, but little continuity was maintained. There was no Research Division. When the Farming Systems Research Project was designed, on-going projects included the USAID/IBRD-funded Thaba Bosiu project, the UN/FAO Senqu project, the Khomokhoana project funded by UNDP/Sweden, the Canadian Thaba Tseka project, and the UK irrigation project. These projects devoted efforts to both research and production activities, and by 1979 a considerable amount of information about agriculture had been generated. The design team stated in the FSR project paper:

> "A substantial and surprising amount of information and data has been accumulated through the activities outlined above. However, a critical problem that exists within the MOA today is the lack of coordination of research activities and the resulting loss of maximum utilization of results produced. This problem can be attributed to the absence of a strong centralized research institution and the lack of resources to create one. This is particularly true regarding the availability of well-qualified research personnel."

The project designers recognized not only the problems of carrying out a viable research program without a centralized research institute, but also the difficulties in establishing one. As stated in the project paper:

> "Problems and deficiencies of the Research Division include (1) inadequate office and laboratory space; (2) the lack of scientific equipment; (3) insufficient operating supplies; (4) the lack of an approved, firm budget at the beginning of the fiscal year; (5) the lack of opportunity for the officer in charge to defend their budget needs before the appropriate administrative officers in the Ministry of Agriculture; and (6) the already noted serious lack of coordination of research and activities among donor agencies and between agencies and the MOA."

With the limitations and needs of the existing research system identified, the task facing the project designers was how to overcome these constraints and help the GOL attain national goals. The project was directly related to the goal "to improve the quality of rural life." Progress toward this overall goal was to be measured by evidence of better nutrition for rural families, more children from rural areas attending school, and the fulfillment of aspirations of rural residents.

The design team felt a major weakness of many other projects in the country had been "their tendency to provide too many inputs and

services to the farmer rather than working within the narrow resource base of Lesotho." With the recognition that heavily-funded projects, which did not involve farmers' ideas and cultural and economic constraints, had little lasting impact on agricultural development, the purpose of the Farming Systems Research Project was stated as:

> "The purpose and principal focus of this project is to create more productive agricultural enterprise mixes which are acceptable to farmers, sensitive to farmers' management ability, appropriate to the resources available, and protective of the land base. It is through farmer adoption of the area-specific farming systems recommended by this project that the objective to increase rural incomes from agriculture will be met. At the end of the project, it is expected that at least five percent of the farmers in the project's prototype areas will be using the systems developed."

One of the expected outputs of the project that would contribute to achieving the purpose was the establishment of a Farming Systems Research Unit within the newly organized MOA Research Division. This unit was to:

- determine research priorities by considering social and economic aspects as well as biological factors;
- develop a system of publishing and disseminating research results to all relevant groups;
- interact with international centers such as CIMMYT, ICRISAT, IITA, and ILRAD to utilize their expertise, biological material, and training capabilities to aid agricultural development;
- investigate technology suitable for the different ecological zones of Lesotho;
- determine methods for educating farmers in improved methodology and evaluate the effectiveness of these extension programs;
- send 16 nationals for long-term training for B.S. and M.S. degrees, and provide short-term training for at least 10 others; and,
- establish an Agricultural Research Library to provide a repository for agricultural literature and centralize the findings of various projects and Ministry divisions.

The FSR Project planners envisioned progress would occur in five stages. Phase I would include the signing of the initial Project Agreement and the arrival of part of the field team. The GOL would be involved in the activities during this stage, which were to include starting construction of technician housing, office space, laboratories and the library, the establishment of a recurring budget, identification of national staff members, selection and departure of

initial U.S. trainees, and approval of the cooperator field staff. Phase II was considered to be the "start-up" stage, in which the project areas would be selected, contacts would be made with village leaders, the coordination with MOA divisions initiated, and the team members would arrive in Lesotho. The year-long Phase III was to be when the technical staff addressed the biological, cultural, and economic problems through surveys and analysis of existing data and made plans for interacting with rural people in the prototype areas. Research Extension Assistants (REAs) were to be assigned to each prototype area, construction of field facilities initiated, and equipment purchased. Phase IV was planned to be a period of intensive field work in the prototype areas that had communication with the rural people as a major goal. This activity was to continue into the 31 month Phase V. During the last 6 months, October 1983 to March 1984, "an intensive effort will be mounted to prepare a program for continued development of farming systems beyond the life of the project".

The task that the USAID, GOL, and WSU administrators faced at this stage was to formulate and coordinate plans for implementation and support of the program developed by the project design team.

2. Program Implementation

a. 1979 to 1982-83

Project implementation was delayed for a year and the contract was signed in March 1979, not 1978, as originally planned. The first six team members arrived in the country in July 1979. Additional delays were caused by the lack of housing and office space. The team members moved from a hotel into houses in September, and into the new office building where adequate space was available in June 1980. In retrospect, the start-up process would have been facilitated if fewer team members had arrived at one time, and if the Team Leader and Administrative Assistant could have been in Lesotho to make arrangements prior to the rest of the team's arrival (R. Butler, End-of-Tour Report). As is common with such efforts, the negotiation for participating nationals, construction of facilities, and recruitment of team members took longer than expected. An account of the project's activities is provided in this section of the report. Detailed descriptions of programs are reported in other sections.

(1) Personnel

The Team Leader, Administrative Officer, Marketing Economist, Extension/Communication Specialist, and Agronomist arrived in-country in July 1979, followed by the Range Ecologist in mid-August, the Social Analyst in mid-September, the Animal Scientist in January, 1980, and the Farm Management Economist in May 1980. The first Marketing Economist was evacuated for medical reasons in January 1980, and the vacant position was not filled until August of that year. The expatriate research team listed in the 1979-80 annual report was:

Team Leader - Robert Butler
Agronomist - Alvin C. Law
Farm Management Economist - Joel C. Plath
Social Analyst - Lorna M. Butler
Animal Management Specialist - Earle Klosterman
Information/Communications Specialist - Seth R. Beckerman
Marketing Specialist - Peter Wyeth
Range Ecologist - James Tiedeman
Administrative Officer - Keith W. Brandon
Librarian - Margaret G. Norton (in-country consultant)
Administrative Services Supervisor - Renate Winch (in-country consultant)
Range Ecology Graduate Student - Ron Wieland

Nationals in the Research Division working with the FSR Project team members included:

Crop Production	Animal Science and Ecology
Trower Namane	Molomo Molopo
M. M. Kotsokoane	L. Mohapi
J. N. T. Peshoane	V. Ramakhula
S. D. Mtsambiwa	T. Matoane
B. N. Ndimande	M. Motselabane
I. M. Mots'oane	
S. S. Maboee	
F. Nkuatsana	
P. Namane	

Administration	Farm Management
W. P. Nts'ekhe	A. S. Sefeane
S. B. Mkhize	L. D. Ts'iu
S. Ntlaloe	M. Ntoanyane
T. Jobo	
H. Letsie	
M. Tshabalala	
B. Mokhachane	

Engineering
J. M. Letsoela
P. Mokenela
K. Makhabane

Librarian	Rural Sociology Associates
Francinah M. Thabisi	Nthope Mapefane
	Thope A. Monaheng

Basotho staff employed by the FSR project were:

Field Enumerators	Thabiso Lekhanya
	A. Khalane

Bookeeper and Office Ass't. Thapelo Moshoeshoe

Having REAs (Research Extension Assistants) in the prototype areas to liaise between farmers and researchers was a key concept in the project plan, but the transfer of individuals to fill those roles was delayed for 1.5 years. The October/December 1980 quarterly report states: "It has taken 16 months of negotiations with the Ministry to have the REAs identified and assigned to their new positions." The delay in assigning REAs created problems during the 1980-81 growing season because no one was available to explain program activities to farmers at the critical spring planting time.

The slow response of getting capable persons into the REA positions created problems that were, unfortunately, compounded by a rapid attrition of REAs. The number in each prototype area dropped from two to one during 1981. It remained at that level most of the remainder of the project and at no subsequent time were there two REAs in each prototype area as originally planned. Changing REAs disrupted the continuity of the program and was especially harmful with only one per prototype area. To help compensate for the shortage of REAs, Peace Corps Volunteers were stationed in the prototype areas and have been at one or more of the locations since 1982.

The problem with obtaining and retaining REAs was in part due to a misunderstanding between the donor, contractor, and the Ministry. The farming systems approach to helping the rural population was a marked change from former development projects, and in reprospect it is clear that it should have been discussed and thoroughly understood by all invloved parties. The philosophy of FSR is expressed in the 1979-80 Annual Report:

> "Farming Systems will not 'take' any farm land from farmers. The team will do research in cooperation with farmers on their fields, but will not do the work or provide equipment. FSRP is a research project, not a development project. It differs from past agricultural development projects in that the only thing that is given away is knowledge. FSRP will not do any farming for farmers, but it will work with cooperators to improve their farming practices. FSRP will not provide tractors or combines, will not build roads in the village areas, and will not build houses for village people. FSRP will not dig wells or pipe water, but will act as a facilitator if villagers want to contact appropriate government ministries or organizations which respond to these kind of needs."

Personnel changes in the Research Division, the USAID mission, and on the team occurred during the 1979/82 period and had varying effects on the progress and thrust of the project. Some of these were the result of an external review held in April 1981.

During the first year of the project four individuals filled the post of Acting Director of Research, and three different Research staff members held the position of Acting Deputy Director. This lack of leadership continuity was especially disruptive to a newly formed division that was in the process of establishing a program and credibility with the Ministry. The Team Leader notes some of the

difficulties in the 1979-80 report to WSU: "When the team members arrived, the Research Division had no organizational chart and no indication was given how FSRP would fit into the Division. It was not until February 1980 that an organizational chart was approved by the PS/MOA." The project paper had described an organization within the Research Division in which the FSRP team would be in one section. The organizational plan that was adopted by the MOA did not provide for a separate unit, but rather located the team members in various sections. This had the advantage of placing expatriate advisors in daily contact with counterparts and giving an entire section the benefit of their expertise, but did increase the problem of maintaining the identification of project goals separate from those of the Research Division. It also created managerial problems in such areas as the use of vehicles and other project-purchased equipment.

The USAID Mission in Lesotho also had changes in personnel during the first year of the project. Both the Mission Director, Frank Campbell, and the Agricultural Officer, Harold Jones, who were in-country when the first team members arrived, left in 1979 and were replaced by Frank Correl and Ken Sherper as Mission Director and Agricultural Officer respectively. In January 1980 Jim Dunn arrived as the Assistant Agricultural Officer. The first Team Leader, Robert Butler, notes in the 1979-80 report to WSU that Campbell and Jones spent considerable time with him discussing how the project was proceeding and indicating how they saw the project implementation. "Great stress was placed on integration within the Ministry and especially the Research Division. It was pointed out that Basotho should be involved at all times even if it required a longer time for accomplishment." When Correl and Sherper arrived they met with the team and emphasized that "they were in country to be facilitators, and to make GOL contacts that would be difficult or impossible for the Team Leader and FSRP personnel". Jim Dunn was assigned as the project contact after he arrived in country. The support from the Mission was good, but communications were not always what was needed and the expectations of keeping the Mission informed about program activities were not clear.

The team composition changed during the 1979-82 period as individuals finished their two year assignments and replacements were selected to fill needs that had become apparent after the start of the project. The Social Analyst position was vacated in September 1981 and the position was not refilled. The Information and Communications Specialist left in July 1981 and the position altered to that of an Extension Education Specialist, which was filled in October of that year. The first Team Leader on the project left in November 1981 and the position was filled early in 1982. The roster of personnel from the 1982-83 report indicates changes that occurred during the three years. The graduate student, Ron Wieland had returned to the U.S., and some of the nationals were in the U.S. on long-term degree programs. The staff of the project and principal Basotho counterparts in 1983 were:

Expatriate Staff
J. Clark Ballard - Team Leader
David Holland - Farm Management Economist
Earle W. Klosterman - Animal Scientist
Lou Ann Pasquan - Administrative Officer
James A. Tiedeman - Range Ecologist
Gordon A. Van Epps - Agronomist
(replaced A. G. Law)
Keith E. Wallace - Agronomist
Peter W. Wyeth - Marketing Specialist
David V. Youmans - Extension Specialist
Alvin G. Law - Agronomist (left post September 1982)
Joe Carvalho - Graduate Student, Farm Management
Cheryl Valdivia - Librarian
Elizabeth Arnold - Secretary (Part-time)
Elizabeth Jackson - Secretary (Part-time)
Lynda Mabbs-Zeno - Secretary (Part-time)

Basotho - (Principal Counterparts)

Administration
W. P. Nts'eke - Director
M. Matli - Deputy Director
I. Mpetla - Administrative Assistant

Agronomy
D. T. Maboee
E. Mofoko
S. S. Moima
T. Namane
E. Pomela

Animal Science
M. Molapo
L. Motjope

Extension
A. Sefeane
L. D. Ts'iu
C. Ramakhula

Farm Management
M. Ts'iu

Horticulture
M. Kotsokoane
M. Mots'oane

Library
T. Sematlane

Marketing
N. Moletsane

Range
M. Manoto

The breakdown of staff by sections in the 1982-83 report as compared to the one for 1979-80 is indicative of how progress had been made in organizing the Division into functioning sections and solving administrative problems in FSR Project and Research Division relationships.

Basotho students who were sent to the states for B.S. and M.S. degrees during the first three years of the project were:

T. Jobo	B.S., Agricultural Economics
M. Motsamai	B.S., Agricultural Economics
M. Moleko	M.S., Animal Science

E. Mokheseng	B.S., General Agriculture
	M.S., Agricultural Extension
T. Namane	M.S., Agronomy
S. Nkofo	M.S., Horticulture
(name changed to S. Sekoli)	
M. Ntoanyane	B.A., Agricultural Journalism
	M.S., Agricultural Extension
V. Ramakhula	B.S., Range Management
M. Tshabalala	M.S., Rural Sociology

In addition to the people sent to the U.S., F. Thabisi completed training as a librarian in a diploma program at the University of Botswana, and K. Mohlakoana was at Eggerton College, Kenya, in a Diploma in Agriculture program. Winston Nts'ekhe returned in 1980 with an M.S. degree in Agricultural Economics and was appointed Director of the Research Division. Deputy Director Musi Matli, received a Master's degree in Agronomy in 1981.

Sending some of the best people in the Division to school for degrees had a negative impact on the research program at the time, but was considered an investment in the future.

Short-term and informal training of Research staff was an important aspect of the institution-building process. This was conducted by team members and consultants in the areas of photography, experimental design, agricultural subject matter, and extension methods, and through daily contact, many other aspects of conducting agricultural research and extension programs. Several individuals attended short-term training courses outside the country. The 1982-83 report lists people who had participated in these specialized courses and workshops:

A. Sefeane	Extension Methods	USDA short course	1980
L. Pachaka	Extension Methods	USDA short course	1980
M. Koali	Extension Methods	USDA short course	1980
L.D. Ts'iu	Extension Methods	USDA short course	1980
A. Mathaba	Soils	Univ. of Nebraska	1982
M. Mofolo	Soils	ICRISAT,India	1982
L. Matsoso	Soils	ICRISAT,India	1982
E. Mofoko	Agronomy	CIMMYT, Mexico	1983
L. Nqwili	Entomology	Purdue	1983
C. Ramakhula	Extension Methods	Univ. Missouri/WSU	1983

The training received in these courses improved staff skills, and combined with the practical experience of the older research officers, did much to enhance the capabilities of the Division.

Consultants from WSU and elsewhere were very helpful during the early stages of the project in correcting administrative problems and providing expertise needed to initiate technical programs. Advice from two of the project paper authors was very helpful in clarifying the intent of certain parts of the project to both USAID and GOL personnel. Interaction in Lesotho between WSU administrators and the

USAID Mission was necessary to finalize financial and personnel agreements. Technical assistance in the areas of soil, agronomy, and range were fundamental steps in initiating research programs. Individuals who served as consultants during the first two years include:

L. F. Rogers	Agricultural Economist (PP author)
R. L. Preston	Animal Scientist (PP author)
W. Bath	On-campus Coordinator
J. S. Robins	Dean, College of Agriculture, WSU
J. C. Engibous	Agronomist
B. F. Roche, Jr.	Range Management Specialist
C. Mack	Soil Scientist
D. Townsend	Assistant Project Coordinator
I. Weir	Data Analyst

During 1982/83 the project benefited from more consultants in the areas of extension, statistics and experimental design, and contract management and administrative matters. Individuals who were involved included:

T. Trail	Extension Specialist
T. Russel	Statistics and Field Plot Techniques
J. Ozbun	Dean, College of Agriculture, WSU
W. Bath	On-campus Coordinator
G. Johnson	Business and Finance

In addition to the people who visited Lesotho, many others at WSU contributed to the project. These included the Extension secretarial and clerical staff, the College Business and Finance Office, the International Program Development Office, and various departments that supplied technical advice and materials.

(2) Prototype Areas

A major feature of the project design was the development of a research area, or domain, in each of the three primary ecological zones of Lesotho: lowlands, foothills, and mountains (Fig. III-A-1). The GOL selected the sites in 1979 with little input from USAID or FSR Project personnel. The criteria on which the selections were made are known only to those nationals who were directly involved. The term "prototype areas" was used to describe these areas. As stated earlier, there was to be limited input into the prototype areas (PA). To provide some field facilities, a small parcel of land was obtained to construct REA housing, and a multipurpose building to store equiment and conduct training. The buildings were finished in late 1982 and early 1983, with the Molumong site the only one with water piped into the buildings. The completion of these prototype buildings considerably improved conditions for on-farm research, especially in the remote Molumong PA. The 1979/80 Annual Report described the three prototype areas:

Figure III-A-1. Farming Systems Research Project prototype areas.

Siloe--the lowland area. The Siloe area is perhaps the easiest place to get to of all three of the areas. However, this lowland area, which is the largest and most heavily populated of the three, like the foothill and mountain areas, has many villages that are accessible only by walking. Siloe itself is a small village on the road between Mafeteng and Mohale's Hoek, about 150 km from Maseru, approximately a 2-hour drive. Most of the road is tarred.

Although designated as the "lowland" prototype area, the elevation ranges from 4,900 feet at the southeastern border to 6,900 feet at the top of Mabolka Mountain. Of the three prototype areas, Siloe has the greatest area of level to gently sloping land which will support agriculture, but also the lowest and most variable effective rainfall, a problem which is compounded by soils of low water holding capacity.

Nyakosoba--the foothills area. This area is the closest to Maseru in a straight line, but is difficult to get to because of an extremely rough road. The government has announced that a new tarred road will soon be constructed from Roma to Ramabanta, and will pass through the middle of the prototype area. Completion is estimated at 2-3 years from now. (That road is now completed).

The elevation range in this area is 6,000-8,727 feet, with the majority of the cropped land at an elevation of less than 7,000 feet. The soils in the Nyakosoba area are deep, and of the three prototype areas, probably the best for crops. Typically, fields are on the slopes of very wide river valleys. This area has the most uniform rainfall pattern of the three PAs, and the longest growing season.

Molumong--the mountain area. This area is the farthest from Maseru--a full day's drive over mountain roads which are at times marginal. Because of the time involved in getting to this area, the team members often send vehicles a day early, and fly to Mokhotlong, about a 45-minute flight.

There are three major types of topography in the Molumong area: deep river valleys, gentle to moderate slopes, and steep, high-elevation mountain areas. The elevation range in the area is 6,500-10,662 feet. Molumong is only 20 km from the town of Mokhotlong, but it is 1.5 hour's drive because the road is rough and crosses the deeply-cut Sehonghong River. The slopes of the deep valleys are used primarily as rangeland, and most people live and farm on the toe slopes which lie between the deep valleys and high mountains.

Erosion is not extensive in this area, but there are large active dongas present in several areas. Erosion is a problem which has been accentuated by the tilling of steep mountain slopes (20-40%) without effective terracing. Much of this steep farmland has probably been tilled only recently as the pressure for farmland increases.

Farming Systems Prototype Areas

	Siloe	Nyakosoba	Molumong
Ecological zone	lowland	foothills	mountain
Administrative district	Mohale's Hoek	Maseru	Mokhotlong
Population[1] (1976)	5,082	3,370	1,872
Households	977	648	360
Number of villages	31	41	17
Extension staff assigned to entire district	37	44	23
Extension staff assigned to prototype area	1	0	3
Area (acres)	23,500	14,794	18,138
Area (hectares)	9,747	5,987	7,340
Elevation range (feet)	4,900-6,900	6,000-8,727	6,500-10,662

1. Estimate based on 1976 census.

The extreme difficulty in getting personnel and materials to the mountain PA at Molumong was a constant problem to researchers. Lack of communications between the three PAs and the main station at Maseru made frequent trips to the areas necessary and exacerbated the problem of insufficient field-based research staff. The lack of communications was especially serious in cases where immediate action was needed, such as outbreaks of insect pests, or sudden weather changes.

(3) Research Division--Facilities and Farm

The facilities for the FSR Project and Research Division were inadequate when the team first arrived in 1979. A new building was constructed and dedicated by the Minister of Agriculture in October 1981. This building provided office space for the Library, Marketing, Extension, Plant Protection, and Rural Sociology Sections, administration, and clerical and accounting support staff. Two laboratories for Plant Protection and a conference room were also included in the building.

The research farm is located approximately 0.5 kilometer from the Division headquarters along the Caledon river. The 20-ha farm was subdivided into plots and the fields leveled to provide better research conditions. The supervision of the farm and its management, record keeping, and land allocation was largely done through the Director's Office with little input from the users except as they expressed needs for plot land.

Both project and contract funds were used to equip the Research Division. Vehicles, both four-wheel drive for field work and two-wheel drive for administrative use were bought. In addition, research capabilities were increased by the purchase of a John Deere tractor, two small Gravely tractors, a grain drill, a land leveler, a flex harrow, a 2½ ton truck, three motorcycles, and miscellaneous hand tools. A telex was installed in the FSRP office. Other items for the offices and library included library furniture and shelving, a copy machine, and typewriters.

(4) USAID--External Review

The project was reviewed by an external evaluation team in the spring of 1981, with a report prepared in April of that year. The team members were Cal Martin, REDSO/EA, and Ken McDermott, DS/AGR (co-team leaders and Ag. Specialists); Ned Greenley, Anthropologist, REDSO/EA; and Tom Bebout, Financial Analyst, REDSO/EA. Observers who worked with the team were; Thabo Moeketsi, Project Coordinator, GOL/MOA; Orville Young, Director, Cooperative Extension, Washington State University; Pat Hinnen, Planning Advisor, MOA; and Elliot Mokhachane, Ag. Section, USAID.

The problems identified in the earlier sections of this report did not escape the attention of the review team:

> "The major problems encountered by the Project, as determined by the evaluation team, have been in defining a short- and long-term agricultural research policy and strategy, the slowness in selecting participants for academic training, the initial confining of project activities to the Prototype Areas, and limited number of skilled MOA professionals assigned to the Research Division. Another area that the evaluation team considers to be a problem is in the overall management of the Project affairs. It seemed to us that the management (Contractor, MOA and USAID) found it difficult to coalesce efforts in directing and guiding the Project for establishing an unified approach in planning and implementing activities at the National and Prototype Area level."

External factors that had hindered the project's progress were also identified by the team:

> "As a result of this low level of involvement of farmers in the economy, MOA research policies and priorities are not as advanced as they might be. The GOL as well, has yet to approve a

clear set of agricultural policies, despite a draft of such strategy in the 5-year Development Plan. The research organizational base in agriculture is extremely limited, personnel made available to pursue careers in research are few, the policy concerning what areas merit intensive research effort is undefined. Current trends in small farmer agriculture show a decline in productivity over the past several years. The reasons for this may be many and varied and may reflect the inability of the MOA to adequately address the real concerns of the sector.

"Thus, regarding host government priorities and socio-economic conditions, there have been, unfortunately, no major improvements since project design. In addition, problems still persist which the project design team identifies as important. It was assumed in the project design, for example, that prototype areas would be selected in areas where there would be access to inputs and markets. The final selection of the three areas omitted this requirement. Also assumed was the availability of previous research which the Contractor could draw upon, the evaluation team has found to be minimal, although the Director of Research has stated that it is more a matter of researching out the information rather than unavailability. Problems with donor coordination and ability to prepare timely research trials which are geared to the yearly agricultural cycle have also been considerable."

The review team recommended abolishing the concept of a Farming Systems Research unit within the Research Division, and instead have the entire Division adopt an on-farm, farmer-oriented policy; to increase the number of agronomists on the team; and to develop mechanisms for closer decision making about direction and policy between the contractor and the Research Director. The review resulted in an amendment to the original project agreement in November 1981. The principal elements of the amendment as stated in the 1981/82 Annual Report are:

"This Project is to develop a program of testing and introducing to farmers innovations that explicity take into account not only biological and technical factors, but human factors as well. The human factors include such ones beyond the farm as: (1) community structures, norms, and beliefs; (2) accessibility and capability of external institutions such as input supply systems and produce markets. The revised approach of the Project is to work under the Research Division towards the goal of added Farming Systems Unit per se. This means aiming at the development of the entire Research Division as a national institution. Further, it is accepted that the introduction of research recommendations is a continuous process based on examining existing farming systems and leading to incremental improvements in them. Second, the revised approach extends the focus of field research from being limited to the prototype areas exclusively to including work in other areas of Lesotho, where

appropriate and as available resources allow. The three prototype areas will still be the leading locations for project field research. The Research Division will incorporate into its research efforts, first, systematic study and understanding not only of what the current systems of farming are, but why those systems are now employed in order to be able to make breakthroughs for more profitable farming practices and systems. Second, the Division will incorportate on-farm field research into its program.

"With the addition of these two components to its research operations, the Research Division will have within its purview, all the necessary elements of research necessary to undertake the farming systems approach. Both individual research activities must be more fully developed and the linkages among the various elements in the research must be strengthened. Consequently, the Research Division and the project team will undertake development of the four basic components of the research system."

(5) Project Progress

The project made considerable progress in establishing a research program and initiating necessary activities during the first three years in spite of the many problems it faced in getting underway. By the summer of 1982 the major administrative and coordination problems that had plagued the project from its beginning had been resolved. A Director of Research had been appointed and was in the position on a permanent basis. The direction of the Research Division and the role of the FSR Project had been determined, and was understood by most of the MOA and USAID staff and team members. The Assistant Agricultural Development Officer at the USAID Mission had been appointed as the contact person for the FSR Project and was in frequent contact with the Chief-of-Party.

The training of Basotho counterparts was underway with nine individuals enrolled in degree programs in universities in the United States, one was obtaining a diploma from the University of Botswana in library science, and several Research staff members had participated in short courses and informal on-the-job training by team members. One person had completed a Master's Degree program and was appointed Director of Research.

Field activities were continuing to grow in scope. The three prototype areas had been selected, the residents had been introduced to the project team members and their counterparts, meetings had been held to acquaint them with the program, and a baseline survey had been conducted to collect data. Village agricultural committees had been formed as a method for opening a two-way communication channel between researchers and rural residents, and an extension training program for farmers had been formulated and was underway. Staff housing at the prototype areas had been completed and was in use.

Activities included in the 1981/82 Annual Report as underway or in the final planning stages were:

- The Agronomy Section was conducting weed control studies, variety comparisons, and seedbed preparation trials.

- The Animal Science Section had cattle pens and scales placed in each prototype area. Preliminary trials with farmers had been conducted to determine interest in supplemental feeding and fodder production by farmers. Hominy chop (maize bran from the milling operation in Lesotho) had been introduced as a source of feed during drought conditions, and a joint project with the Range Section had been started to determine the value of supplemental feed for breeding ewes during the winter months.

- The Extension Section was continuing to train prototype-area farmers through the Village Agricultural Committees and encouraging the publication of information circulars for Extension field personnel. At the request of the Ministry of Agriculture the Section had conducted a training school in both technical agriculture and extension methodology for District Extension Officers and Research Extension Assistants. It was also routinely interacting with other Sections to help with on-farm trials and other activities taking place in the field.

- The Farm Management Section had initiated a farm records program to study farming methods being practiced in the prototype areas and the constraints and economics of various enterprises. Personnel had participated in conducting the baseline survey, and in a cooperative study with the Conservation Division into the economics of no-till maize production.

- The activities of the Marketing Section included studies of the disposal of crops produced by 120 farmers in the prototype areas and a cooperative study with the Basic Agricultural Services Project (BASP) into the inputs and commodity marketing in the Leribe and Butha Buthe region. It also had helped with the Baseline Survey and participated in deliberations about establishing marketing policies at a national level.

- Range Section activities included the establishment of a sheep trial with cooperating farmers to evaluate and demonstrate the value of proper stocking rates on ranges, the introduction of a rotational grazing system in the Nyakosoba prototype area, and continuing evaluation of the yield of introduced grasses and legumes. A long-term study of range trends and vegetation classification had been initiated and the first phase of a brush control study had been completed.

The FSR Project was functioning as a stimulus to the development of the Research Divison and making progress toward the stated goals in 1982. This is attested to by the Research Director in the 1981/82 Annual Report.

"The RD appears to have made appreciable progress since the end of 1979 when the division was officially formed. The alterations made in the FSRP agreement appear to be helping the RD to progress fast. The new Team Leader/Advisor's role in the harmonious functioning of the RD warrants special mention. When the RD trainees begin returning from their universities the division should be able to cope very well with most of its expected duties. All the trainees still in school are doing exceptionally well. The RD is geared towards increased productivity in future."

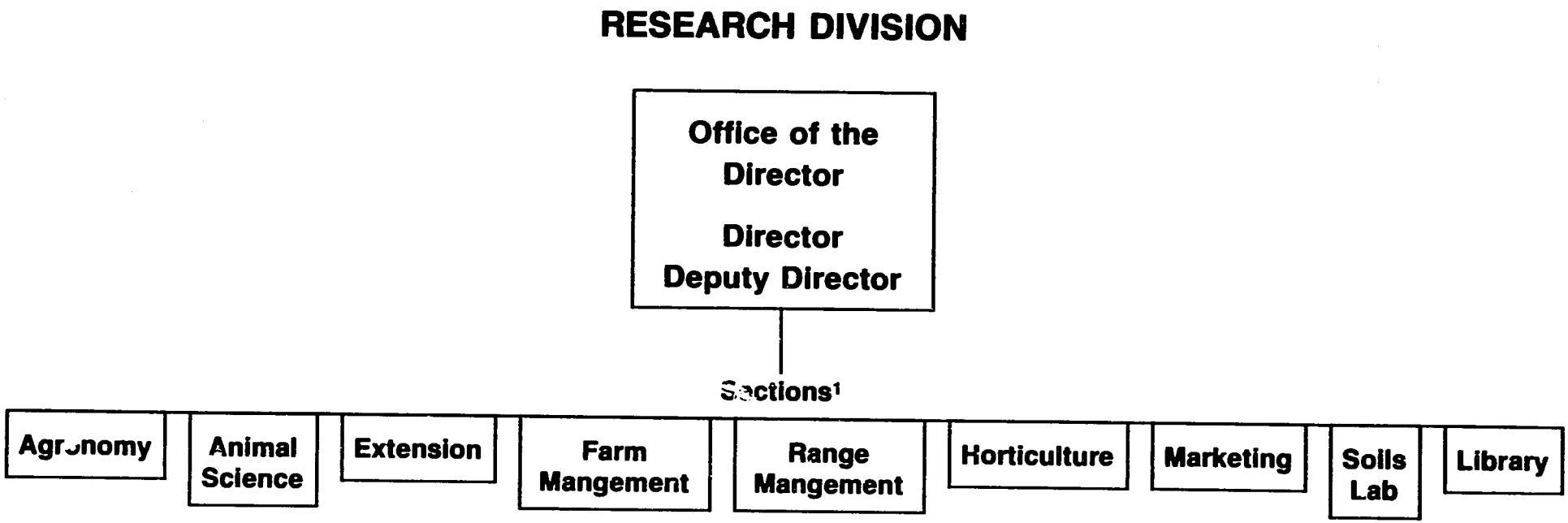
b. 1982-83 to 1986

During the last half of the 7-year project the farming systems team and program were integrated into the Research Division. There was one staff and one program. Work plans and reports were prepared according to sections and no distinction was made between FSR activities and those of the Research Division. This arrangement agreed with the recommendation of the 1981 external review team.

The organization of the Division had been developed with sections representing the various disciplines and their scope of activity (Figure III-A-2). In practice the bulk of administrative decisions were made by the Director of Research with little input from Section Leaders. This was in part due to the lack of training and experience of some of the Section Leaders, a situation that will change when staff on long-term training programs return. In June 1985 the Ministry of Agriculture and Marketing reorganized into departments made up of divisions (Figure III-A-3).

The Ministry adopted a research policy in September 1983 (RD-B-24). This policy provided overall program direction to the still-developing Research Division. This document stated that the Division would focus on applied research that considered problems which are of direct relevance to farmers. The identification and understanding of farmers' economic and environmental circumstances would be integral parts of the program, as would on-farm testing of promising technology. Specific administrative objectives are:

- Establish a functional research coordinating council which authorizes agricultural research programs.
- Develop a Lesotho Agricultural Research directory.
- Establish research in all relevant agricultural disciplines.
- Promote those disciplines which contribute most to the economic improvement of Basotho farmers.
- Organize staff training.
- Promote a friendly professional relationship among staff at all times.



[1]Each section is administered by a Section Head.

Figure III-A-2. Organization of the Research Division of the Ministry of Agriculture and Marketing.

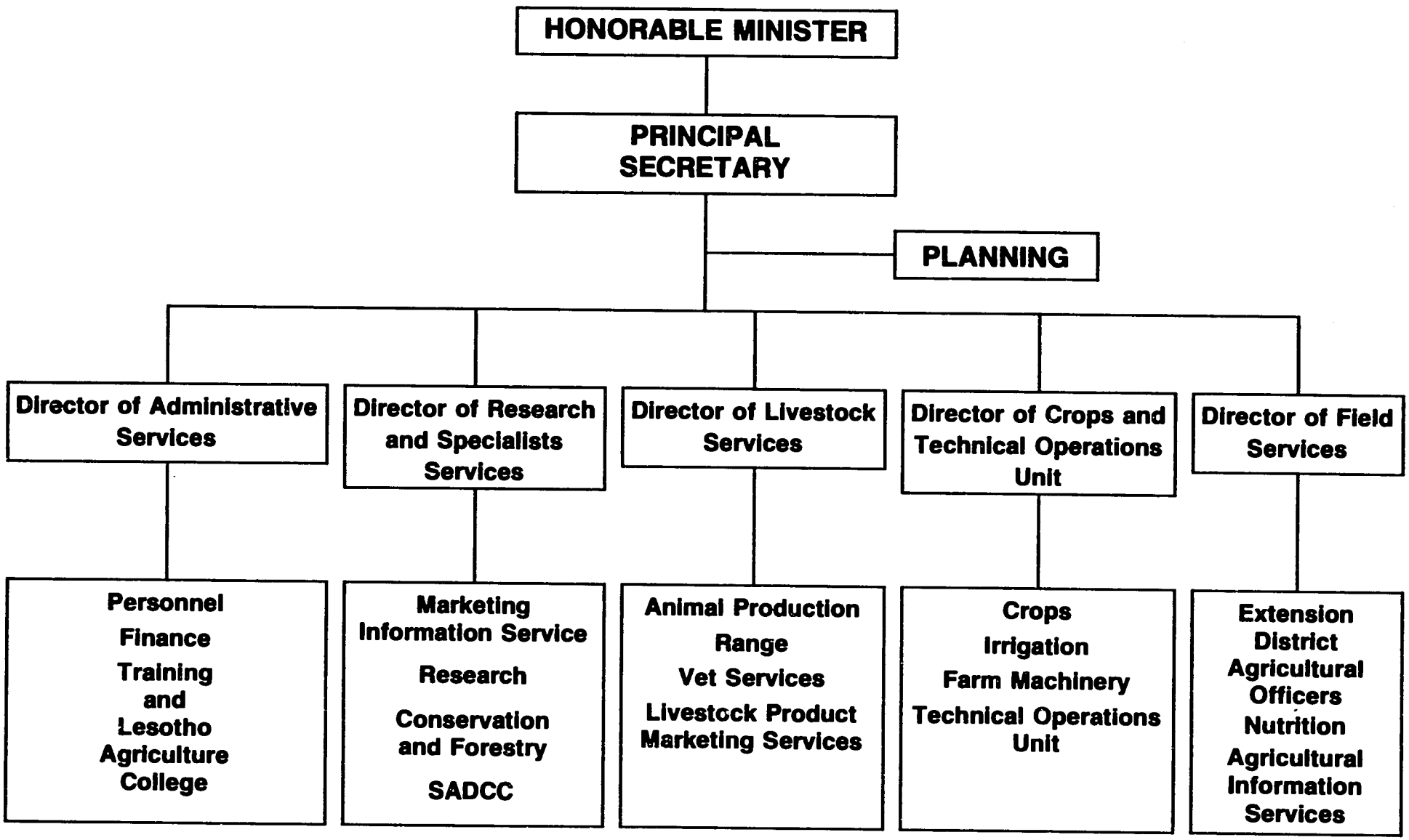


Figure III-A-3. Organization of the Ministry of Agriculture and Marketing.

- Collect all final agricultural research reports.
- Monitor field trials and demonstrations by suppliers of agriculutral products and technologies.
- Support all desirable programs.
- Advocate, when and wherever possible, for less costly agricultural products of high quality which ensure a high safety level.
- Cultivate friendly relationships with suppliers and honor all legal orders made by the staff.

Technical objectives of the Research Division are:

- Identify, in collaboration with farmers, priority agriculural problems and seek solutions.
- Make farming more profitable for Basotho farmers.
- Seek means and ways of increasing agricultural productivity in Lesotho.
- Help determine means and ways of achieving the Lesotho national goal of self-sufficiency in food-stuffs produced in Lesotho.
- Devise/improve farming systems which, while increasing both productivity and profitablility, would ensure preservation of the land-based resources.
- Investigate and develop appropriate systems for reclamation of depleted or otherwise unproductive lands.
- Investigate and help develop agricultural techniques suitable for Lesotho conditions.
- Develop and periodically update cropping guidelines for Basotho farmers.

The project was extended for 2 years at the request of the MOA and USAID and on the recommendation of an external review team that evaluated the project during December 1982 and January 1983. Delays in getting the extension approved by USAID resulted in the need for a three month extension with no additional funds in addition to the 2-year extension. This changed the termination date of the project to 31 July 1986.

Various aspects of the project's progress from an administrative perspective are described below.

(1) Personnel

The long-term training phase of the project was quite active during 1982-84 with as many as 15 persons out of the country at one time on degree programs. By December 1983 three people had returned to the Division (excluding the Director and Deputy Director, who returned in 1980 and 1981, respectively), one with a master's degree in animal sciences and another with a B.S. in agricultural extension, and the third with a diploma in agriculture (animal science) (Table III-A-1).

By 1984 six nationals had earned degrees and returned to the Division. This represented an addition to the staff of two B.S. degrees in agricultural economics, one B.S. in range science, and master's in agricultural extension, agronomy, and horticulture. In January 1985 the person with a master's degree in agricultural extension left to become the District Agricultural Officer in the Qacha's Nek District. This left the Animal Science Section with one person trained to the Diploma level as the sole research officer until a M.S degree holder returned from school in September 1985.

During 1985 several more people completed degree programs and returned to Lesotho. The capability of the Division improved considerably with the addition of master's degree holders in rural sociology and animal science. The project also sponsored one person from the Agricultural Information Service in a B.S. degree program, which he completed in December 1985.

Short-term training continued, although at a diminished rate from the earlier years of the project. During 1984 an officer was sent to the United States to attend a USDA short course in marketing and another attended a 3-month course in research management at the University of Zimbabwe. Several others attended 1- and 2-week workshops sponsored by FAO, CIMMYT, and other international centers. Most of these concerned the production of maize and/or sorghum and a few dealt with the analysis of on-farm research results. Several of the research staff and team members attended a workshop on the use of personal computers that was offered by a local business.

The FSR Project team underwent a change with the start of the 2-year extension. Two team members, the extension specialist and the farm management economist, extended their tours of duty and five new expatriates arrived by July 1984. Changes in team composition were: reducing the number of agronomists from two to one; adding a horticulturist; and eliminating the administrative officer and animal scientist positions. A national who had been given on-the-job training assumed administrative officer duties. Guidance to the Animal Science Section was provided by the range scientist and team leader. The FSR/RD staff during the 1984-1986 included:

Table III-A-1. Long-term trainees funded by FSRP.

Name	Discipline	University/Country	Completion date
	(Agronomy Section)		
Matli, M.[1]	Ph.D. Agoronomy	Univ. of Nebraska/USA	Dec 1989[2]
Namane, T.	M.S. Agronomy	Wash. St. Univ./USA	Aug 1984
Pomela, E.M.	M.S. Agronomy	Univ. of Idaho/USA	Jul 1986[2]
	(Animal Science Section)		
Mohlakoane, M.	Diploma	Eggerton College/Kenya	Aug 1983
Molapo, M.	B.S. Anim. Sci.	Wash. St. Univ./USA	May 1986[2]
Moleko, M.	M.S. Anim. Sci.	Wash. St. Univ./USA	Aug 1985
Motjope, L.	M.S. Anim. Sci.	Wash. St. Univ./USA	May 1986[2]
	(Extension Section)		
Ntoanyane, M.	M.S. Ag. Journ.	Univ. of Missouri/USA	Aug 1984
Ramakhula, C.	B.S. Gen. Agr.	Wash. St. Univ./USA	May 1989[2]
	(Farm Management)		
Jobo, T.G.	B.S. Ag. Econ.	Wash. St. Univ./USA	Dec 1984
Majoro, M.	M.S. Ag. Econ.	Wash. St. Univ./USA	Aug 1987[2]
	(Horticulture Section)		
Makhata, H.	B.S. Horticulture	Wash. St. Univ./USA	May 1986[2]
Sekoli, S.	M.S. Horticulture	Wash. St. Univ./USA	Oct 1984
	(Marketing Section)		
Motsamai, M.	B.S. Ag. Econ.	Wash. St. Univ./USA	June 1984
	(Plant Protection Section)		
Pomela, M.L.	M.S. Entomology	Wash. St. Univ./USA	May 1986[2]
Qhobela, M.[1]	M.S. Plant Path.	Kansas St. Univ./USA	Jan 1989[2]
	(Range Management Section)		
Ramakhula, V.	B.S. Range Manag't	Wash. St. Univ./USA	June 1984
	(Soils Laboratory)		
Mathaba, D.	M.S. Soils Sci.	Wash. St. Univ./USA	May 1986[2]
	(Rural Sociology Section)		
Matobo, T.	M.S. Rural Soc.	Wash. St. Univ./USA	May 1986[2]
Tshabalala, M.	M.S. Rural Soc.	Univ. of Missouri	Dec. 1985
(degrees not associated with any specific section)			
Matete, M.P.	M.S. Human Nutr.	Howard Univ./USA	May 1986[2]
Rakuoane, S.L.	B.S. General Agr.	Wash. St. Univ./USA	Dec 1985

1. Degree programs funded by ICRISAT. 2. Expected completion dates. After 30 June 1986 expenses will be paid from LAPIS Project funds.

Expatriates

B. Badamchian	Soils Scientist
R. F. Brokken	Marketing Specialist
J. D. Downes	Horticulturist
C. J. Goebel	Range Specialist
D. W. Holland	Farm Management Economist
D. J. Lee	Team Leader
G. L. Richardson	Agronomist
D. V. Youmans	Extension Specialist
E. Arnold	Secretary (part-time)
L. Mabbs-Zeno	Secretray (part-time)
D. O'Brien	Secretary (part-time)
A. Stephens	Secretary (part-time)
L. Cauley	Computer Programmer (part-time)

U.S. Graduate Students

Allen Dobb	Range
Bonnie Borris	Farm Management
Joe Carvalho	Agricultural Economics
Elizabeth Kirby	Horticulture
David Granatstein	Agronomy

Peace Corps Volunteers

Mark Woods	Horticulture, Siloe
Sheila Woods	Horticulture, Siloe
Susan Dirks	Horticulture, Nyakosoba
Don Irwin	Horticulture, Molumong
Sheila Lyons	Horticulture, Molumong
Jeff Ray	Agronomy, Maseru
Ed Schering	Agronomy, Molumong
Craig Brunetti	Agronomy, Siloe
Amy Mowery	Horticulture, Siloe
Mark Roskos	Engineering (irrigation), Siloe

Consultants

Wayne Bath	Financial and Personnel Management
Orville Young	General Contract Management
Jim Henson	Contract Management - Financial and Personnel
Chris Mack	Soil Survey
Irv Dow	Project Report
Seth Beckerman	Agricultural Information
Dwight Peabody	Weed Control Specialist
Alice Spitzer	Library
John Hunter	Weather Data Analysis
William Ford	Agronomist/Extension

National Counterparts

Administration

W. P. Nts'ekhe	Director (left 5/85)
M. Matli	Deputy Director (left 12/85)
T. Namane	Acting Director

M. Ntoanyane	Acting Deputy Director
M. Mothetho	Administrative Officer
I. Faku	Assistant Administrative Officer

Agronomy
- T. Namane (Section Leader)
- D. T. Maboee
- S. S. Moima
- E. Mofoko

Animal Science
- M. Moleko (Section Leader)
- K. Mohakoana

Extension
- A. Sefeane (Section Leader)
- L. D. Ts'iu
- C. Ramakhula
- M. Ntoanyane
- H. Letsie

Farm Management
- T. Jobo (Section Leader)
- M. Majoro
- P. M. Alotsi

Horticulture
- S. Sekoli (Section Leader)
- M. Mots'oane

Library
- F. M. Thabisi (Librarian)
- T. Sematlane
- L. W. Thetele

Marketing
- M. Motsamai (Section Leader)
- N. Moletsane

Plant Protection
- M. Qhobela (Section Leader)
- T. Lepheana
- M. Ranasike

Range
- V. Ramakhula (Section Leader)
- M. Mabusa
- G. Seutloali

Soils
- P. Namane (Section Leader)
- M. Mofolo

The return of nationals from degree programs enabled them to take a more active part in research planning and implementation. To varying degrees, the team members assumed advisory-type roles during the last year of the project.

In addition to the Maseru-based research officers, personnel located in the prototype areas played a key role in the research program. Research Extension Assistants were a vital link between research/extension and farmers. Two who deserve special recognition for their dedicated work with the project are T. E. Malataliana, who was at the Siloe PA for the life of the project, and Mrs. C. M. Kao, who was transferred to Siloe after several years at the Molumong PA.

Farm Management Assistants have also had an essential part in field activities, B. Molise, M. Khalane, and T. Lephoi have made significant contributions to the program.

In May 1985, M. G. Khadikane replaced S. J. Kao as Principal Secretary and Winston Nts'ekhe, Director of Research was appointed Director of Technical and Specialists Services in the MOA. The Deputy Director, Musi Matli, was appointed Acting Director of Research and held that position until he left in December 1985 for a Ph.D. program at the University of Nebraska. Maseabata Ntoanyane was appointed Acting Deputy Director when Mr. Matli moved to Acting Director. Trower Namane was appointed Acting Director in January 1986. In February 1986, Mr. Matli was confirmed as Director of Research.

The Research Division has gone through the problems common to any newly formed unit. The problems created by lack of organization, uncertain program direction, and the struggle to be recognized as a functioning unit of the MOA have been overcome to a large degree, but further progress in these areas is needed. The shortage of field and laboratory technicians, clerical help and other support services, as well as a shortage of adequately trained scientists is still critical and will take time to correct. The return of the 12 Basotho now in degree programs will do much to enhance the research capability of the Division.

The relationship between the Team Leader and the USAID Mission was improved with the assignment of an Agricultural Officer to have responsibility for the FSR Project. Jim Dunn served in this capacity from January 1980, until September 1984. During 1982 Barry Hill arrived to serve as the Agricultural Development Officer at the Mission and in the same year Edna A. Booraday replaced Frank Correl as Mission Director. These changes had little or no impact on the project as Mr. Dunn continued to serve as the primary contact. Between the time Jim Dunn left and his replacement, Abdel M. Moustafa, arrived and assumed the responsibility for the project, there was a serious loss of interaction between the project and the Mission. There were approximately 6 months during which it was very difficult for the Team Leader to get information about making purchases, personnel matters, and other necessary activities. The situation greatly improved after Dr. Moustafa assumed the position of Assistant Agricultural Officer on a permanent basis in May 1985.

Changes also occurred in personnel at Washington State University. J. L. Ozbun replaced J. S. Robins as Dean of the College of Agriculture in 1982 and in September 1985 J. B. Henson replaced W. Bath as On-Campus Coordinator for the Project. In October 1985, Darlene Townsend resigned as Assistant Campus Coordinator.

(2) Prototype Areas

Work in the three prototype areas had expanded to full scale programs by 1982/83. All the sections were involved at least to a certain degree in field-related activities. The problem of staffing at the PAs was a problem that was never completely solved during the life of the project. The plan to station two Research Extension Assistants at each PA was not successful. The MOA assigned only one

Extension worker to each PA, and turnover of personnel, especially at the Nyakosoba PA, was detrimental to the programs. Because the REA positions were key to the activities in the PAs, it was desirable to have qualified Basotho in that role for training as well as helping the Research Division with its program.

The Farm Management Section stationed Farm Management Assistants in each PA to collect data and monitor field activities. The other sections relied on visits by researchers from Maseru and the REA to make the necessary observations. This was not completely satisfactory because a constant monitoring of on-farm trials is needed to interpret results.

Peace Corps Volunteers were assigned to the PAs in 1982 to help overcome the need for more field-based personnel. This improved communications and provided on-site observers for field activities. The use of PCVs as field personnel was not entirely successful. The major problems were:

- Lack of a clear understanding on the part of the PCVs of what was expected of them.

- Team members' expectations of the PCVs were too high. Most of the PCVs' training and experience was not adequate to handle the task expected and the team members found themselves training volunteers instead of nationals.

- The agency or division to which they were responsible was not made clear to the PCVs, and as a result, they did not identify themselves with the Research Division. This caused some ill-feeling on the part of both Research Division personnel and PCVs.

- Peace Corps and Research Division/FSR administrators did not coordinate the programs of the PVCs adequately and as a result the volunteers in the PAs were often engaged in activities that were not part of the Research Division's program although local residents did not make a distinction. Meetings called by the Peace Corps and PCV vacations were seldom coordinated with research activities.

Because of such problems in 1985 the Director of Research decided not to request any PCVs for 1986. As a result there were no PCVs in the Molumong or Nyakosoba PAs during the 1985/86 growing season. With the advantage of hindsight it is apparent the problem was caused by ommissions rather than commissions. Peace Corps Volunteers did contribute to the program, but their contribution would have been greater and certain individuals would not have experienced frustrations and bitterness if better planning had taken place. The Research Division/FSR and the Peace Corps administrators should have coordinated their programs better so the conflicts could have been minimized, if not eliminated. The Research Division Director and FSR Team Leader should have monitored the assignments made to the PCVs to

be sure the volunteers were qualified to complete them, and that they fit into the overall research program. Finally, the PCVs should have been given clear instructions about who was their immediate supervisor.

During the 1985/86 season, an Agronomy Section field worker was assigned to Molumong and one from Horticulture was stationed at Nyakosoba. While this filled an urgent and immediate need, it did not increase the capability of the Research Division in the long-term. These people were paid by the FSR Project and before the project closed, both took other jobs that offered long-term security.

Physical facilities at the Siloe and Nyakosoba PAs were upgraded by drilling wells and piping water to the houses. A small catchment dam was constructed at the Siloe site and the water was used to irrigate horticulture trials. A small orchard was planted in the spring of 1984 at each of the three PA building sites. Two-way radios were installed at each of the PAs and Maseru in order to increase communications capability. The reliability and usefulness of the radios were disappointing. Transmission between Maseru and Molumong was never reliable because of intervening mountain ranges and weather effects. At the present time the system is nonfunctional.

The inhabitants of the PAs have come to accept the PA buildings as a meeting place for a variety of Extension and Research functions and prefer meeting at these sites than traveling to Farmer Training Centers. The Research Division and FSR Project have established a positive image in these areas and have overcome to a large degree the suspicion of outsiders and government workers that exists in some rural communities.

(3) Research Division--Facilities and Farm

The FSR Project continued to upgrade facilities and equipment in the Division throughout the 1982/83 to 1986 period. Three 4-wheel drive pickups were added to the motor pool in 1984 for use during the 2-year extension and subsequently two station wagons and two double-cab pickups were purchased. All were 4-wheel drive to enable staff to get around the prototype areas and travel secondary roads. The maintenance of vehicles is costly in terms of both time and money. In 1985 a mechanic was hired by the project to maintain both vehicles and farm machinery. A 1980 Puegeot station wagon was totally wrecked in June 1984, and a 1981 4-wheel drive pickup was damaged beyond repair in the March 1985. Control of vehicles and providing transport when it is needed are two problems that have not been satisfactorily resolved. The mandate to work in the distant PAs makes the availability of transportation for researchers when it is needed a top priority requirement for the program.

The facilities of the Division were expanded to include a new equipment maintenance and repair shop, a renovated storage shed for Horticulture, an upgraded Soils Laboratory, and five small greenhouses. A new library building is being planned for construction during 1986 immediately adjacent to the Research Division buildings.

Equipment purchased during the last two years of the project included a John Deere tractor, an offset disk, three sets of ox-drawn Ariana equipment, a small portable thresher, and several thousand Maloti worth of small shop and farm tools. The equipment inventory of the Division was increased during 1984/85 by the addition of an electronic balance, soil moisture probes, a camera, a slide-projector, and an IBM combination typewriter/printer. A Hewlett-Packard computer was purchased in 1983 and an IBM-compatible Columbia computer with 30 megabyte storage capacity in 1985.

During 1985, Soils Laboratory was renovated, and new furniture and some equipment purchased. A major purchase was an atomic absorption spectrophotometer in December 1985 to enable the laboratory to analyze samples for trace elements. The project, in a cooperative effort with the Near East Foundation, helped finance the printing of a book that describes the soils of Lesotho.

The Library collection has grown to nearly 4,000 volumes. Publications from the international centers, development support projects in the U.S. and other countries, papers and reports from other African countries, and reports from projects in Lesotho are routinely sent to the Library. It is recognized by the Ministry as the official repository for agricultural material.

The librarian was sent to the United States in the autumn of 1985 for short-term training in library science with an emphasis on international publications and methods. The course was followed by on-the-job training and consultation with a librarian consultant who spent 4 weeks in Lesotho helping catalog and develop methods for filing reports, occasional papers, and similar matter.

The librarian and her staff perform the valuable service of supervising the printing of Research Division Bulletins, Circulars, and Reports. This is not strictly a librarian's duty but the library staff has been assigned this task. To date, the Division has produced 178 publications which are circulated to other divisions in the Ministry, to USAID, to WSU, and to other African countries. Circulars are designed to meet the needs of Extension field staff and are circulated to all of the approximately 300 Extension agents in the country.

The number of people using the library has increased over time. In addition to the Research staff, it is used by personnel from other Divisions of the Ministry, staff from other projects in Lesotho, government or project consultants, and the staff of other ministries. Students from Lesotho Agricultural College and from the National University of Lesotho are also frequent users. The program has outgrown its physical space and until the new library building is finished service will be limited.

The success of developing a viable research program has created a facility and space problem. This will become especially critical after the students now enrolled in degree programs return to the

Division. There will not be adequate office space in the existing Research buildings for both the expanded staff and team members of the USAID project that will follow this one. Laboratory space is extremely limited for all sections. Even the refurbished Soils Laborarory is not adequate to analyze large numbers of soil samples.

The Research Farm was mapped, roads straightened, and fields leveled. It is of adequate size to meet the needs of the research program for the foreseeable future. A management system needs to be developed and a competent farm manager employed to maintain the facility. Weed control along roads, ditches, and in fields not used for plots is a critical need. One person was sent to the United States in April and May 1985 for experience in operating a research farm, but has not been effective since returning because of ill health. One problem at the Research Farm is theft of experimental crops. This is especially serious with highly valued foods such as maize or melons. Some maize trials in 1984/85 had to be abandoned because of theft. This year additional guards have been hired in an attempt to save some experiments. The loss of a trial after it has been brought to the harvest stage is serious and is discouraging to researchers.

(4) USAID--External Review

Personnel at the USAID Mission were involved with the construction of buildings and obtaining equipment for the Research Division during the life of the project. During the early years of the project, engineers at the Mission, and other USAID staff were heavily involved in designing and implementing the construction of prototype facilities and the office/laboratory building at Research headquarters in Maseru. During the past 2 years their input has enabled water to be supplied to PA houses, and a machine shop, greenhouses, and a storage room for horticultural produce to be constructed at the Division. The renovation of the Soils Laboratory was directly handled by USAID personnel, as was the purchase of several equipment items. Two vehicles, an atomic absorption spectrophotometer, and many pieces of small field equipment and tools were obtained with their assistance.

In addition to supporting the project by obtaining materials that were needed, the Mission was very supportive of training efforts. Through the 7 years the Mission has encouraged Research personnel to participate in and become acquainted with programs offered by the international centers, the USDA, and other countries in Africa and Europe. These activities have been primarily the areas of crop production, especially maize, sorghum and wheat, on-farm research methodology, and training in Extension methods.

The rate of attendance of USAID personnel at FSR/Research activities during the last two years of the project was disappointing. The Agricultural Development Officer and/or the Assistant Agricultural Development Officer rarely attended project-sponsored research activities such as field days and meetings of the division, or accompanied team members to prototype areas, and therefore had little

first-hand knowledge of project activities. This lack of interaction led to a general feeling that the USAID Mission did not particularly care about the program and that its primary purpose was one of a regulatory nature rather than as a cooperator. Even though this was to a certain extent an erroneous perception, it had a negative effect on USAID/FSR Project relationships.

A second project evaluation took place during December 1982, and January 1983. The evaluators were;

Cal Martin	REDSO/ESA	Team Leader/Agriculture Specialist
Dan Galt	Consultant	Farming Systems Specialist
Carolyn Barnes	REDSO/ESA	Social Analyst

The summary in the Project Evaluation Statement provides an idea of what the reviewers found positive about the project's progress and what they felt needed more emphasis. They reported that the quality of research in the Division had improved and that the expatriate team members were serving a valuable role in working with national counterparts in the various sections. The team agreed with the first evaluators that the time-frame to be considered for improving the research capability of the Ministry should be 10-15 years, if not longer. The participant training of nationals in degree programs was proceeding to their satisfaction, but they did express concern about the delay in getting it started. Construction and the purchase of commodities were progressing well and major activities in these areas had been completed.

The evaluation team found some project areas were not progressing to their satisfaction. These included Research/Extension relationships. The summary of the evaluation report stated:

"The MOA Extension Service input into the project has been somewhat deficient. Only one extension agent has remained with the project since its beginning in 1979. As pointed out in Section 22 of this report, it is the team's judgement that the Extension Service should be a full partner of the project rather than having agents seconded to the Research Division."

Although there was some disagreement among Research personnel about whether extension agents should be seconded to Research, there was general agreement that more interaction between extension field personnel and researchers was desirable. It was not possible to have the desired continuous interchange with only one Research Extension Assistant per prototype area.

The evaluation team said that the Baseline Survey conducted during 1980-81 did not provide adequate data to researchers and stated in their report:

"The contribution of data that was to be provided by the baseline study activity to the various offices in the Research Division has been less than desirable..... This study should have provided information to the subject matter scientist in year two at the latest. However, some of it has not yet been analyzed and made available."

Recommendations of a general nature that were made included: a) the development of a Research Policy Statement; b) the formation of an Agricultural Research Planning and Coordination Council (this was also recommended by the 1981 evaluation team); c) hasten the long-term training of nationals through degree programs as much as possible; d) the identification by both national and expatriate researchers of priority crops and problems that exist in each of the prototype areas and design future research accordingly; e) extend project activities to areas outside the prototypes as much as is feasible; and f) evaluate the impact of FSR/E programs.

Although there were areas where the evaluation team felt improvement was needed, their general impression was that the project was progressing well and recommended it be extended for two years past its 1984 termination date.

(5) Project Progress

As the project progressed, various Sections within the Division evolved their programs around identified problems of farmers and available resources. The physical facilities had been developed to the extent feasible for immediate needs, interactions with farmers in the prototype areas had been going on long enough that there was a general understanding of the problems they faced, and as people came back from degree programs, the human resources of the Division were considerably strengthened. Within this setting the sections tended to emphasize what their staff considered were the most important topics in their discipline. In so doing, highly organized interdisciplinary research was not emphasized. A multidisciplinary approach developed in which each of the disciplines researched areas that were of importance, but specific trials and activities were not necessarily discussed and approved by the whole team or Division staff. This development is not in line with the classic FSR approach, but was the outgrowth of several factors:

- The project covered such areas as marketing, extension, and institution building, which are not included in projects that deal only with farmer-oriented concerns.

- After 3 years, the project personnel had developed an understanding of the problems faced by farmers in Lesotho, the need for research to provide answers about production became evident. Solving of these problems required research to be done by scientists working in their particular disciplines.

- The Extension Section actively provided farmers with information about better technology and initiated an extensive demonstration program as a tool for transferring information. (This effort was aided by the decentralization of the Extension Division of the MOA which put both agents and subject matter specialists in closer contact with their clientele groups). Few projects, or research organizations in developing countries in Africa, have an extension component.

- Although the program was not interdisciplinary as an entire unit, there was a constant interchange between the different sections as required to solve problems or to develop research strategies. As a result the program as a whole was a unified effort.

During the 2-year extension from 1984 to 1986, a horticulturist was added to the team to strengthen the effort in that area. There had been horticultural research conducted by Basotho researchers, but this had primarily been done on the Maseru station and little work had been done in the prototype areas. Sections that had been working in Lesotho previously concentrated on key trials that would enable them to draw conclusions from the research, make recommendations to producers, and identify priority research areas for scientists that succeeded them. These are given in detail in other sections of this report, but some general statements about the different programs are provided.

The agronomy research program, like those of all the crop sciences, was severely affected by the drought conditions during 1981-1984. Fertilizer requirements in the three ecological zones of Lesotho were studied, and varieties of maize, sorghum, and wheat were tested. The rapidly-maturing pinto bean was introduced and readily adopted by the farmers. Improved farm equipment was developed for seeding and fertilizer application, and a simple box level was constructed and tested. Better seedbed preparation, proper seed placement, weed control, and the use of fertilizer were identified as realistic management practices needed to increase production.

The Animal Science Section was without personnel after the Section Leader left the Division in January 1985. Prior to this time the section had investigated fattening cattle with simple rations, winter feeding of oxen, supplemental feed for ewes on sparse pastures, and encouraged fodder production. A project to determine the biological and economic feasiblity of small poultry flocks in villages was a primary activity during 1985/86. Cooperative efforts with the Range Section involved fodder production trials and supplemental feeding of sheep.

Farm Management continued to monitor farmers' production economics in the prototype areas through the use of the farm record program and developed production budgets for several agricultual production enterprises. The great interest in irrigation made economic studies of vegetable production especially timely. Total farm production systems were developed with two farmers in each of the prototype areas to test improved technology.

The horticulture program in the prototype areas was primarily an Extension function until 1984, when research under on-farm conditions became part of the FSR project mandate. The production of vegetables in both home gardens and in small commerical plots had been encouraged with considerable success in the prototype areas, but little work on fertilizer requirements, variety adaptability, etc. had been done. The program during the last 2 years was concerned primarily with vegetable production. Potatoes and cabbages were the major crops

studied. A small research orchard was established in each prototype area and at the Research Farm in Maseru.

The Library gained wide recognition as a source of agricultural information and its use has continued to increase. The training of the librarian and hiring two full-time assistants has enabled the staff to keep up with most of the work load. The Library staff has taken over the tasks of supervising the printing of research publications and their distribution. The new Library building that is planned will improve the Library facilities for both the Research Division and the near-by Lesotho Agricultural College.

The Marketing Section's program dealt with country-wide markets and factors affecting their performance and was not confined to the prototype areas. Studies of the marketing channels for wool, mohair, vegetables, animals and animal products, and grain crops were conducted during the life of the project. A slide/tape program for Extension personnel to use in teaching farmers how to improve the quality of hides and skins was produced.

The Plant Protection Section in the Research Division has been an active cooperator with the crop science sections. It did not have an expatriate advisor during the life of the project, but received support from the FSR Project in the form of both funds and advice from agronomists and horticulturists. The research program included trials for the control of cutworms, stalkborers in maize and sorghum, the identification of a nematode infestation in potatoes at the national seed-increase project, and the drafting of a pesticide policy statement and a pest control guide. The section leader left in October 1985 to obtain a master's degree in plant pathology. His return, together with the return of a staff member now getting a degree in entomology, will provide needed strength in this important area.

The Range Section of the Division investigated several aspects of animal/forage interrelationships in Lesotho. Studies included:

- long-term trends in vegetation on grazed and protected sites,
- brush control methods,
- the nutritive quality of native and introduced species at different seasons of the year, and
- possible methods to reduce the impact of mismanagement that would be acceptable to livestock owners.

Range personnel were also involved in Extension activities and successfully introduced the practice of forage production to prototype farmers.

Activity in Rural Sociology was an important part of the FSR/Research program during 1979-82, but was at a very low level or nonexistent during 1982/84. The Social Analyst position on the team

was eliminated and nationals from that section were sent to the U.S. for degrees. The return of an individual with a master's degree in rural sociology to the Division in January 1985 renewed the program. This section will be further strengthened by the return of a second master's degree holder in June 1986.

The staff of the Soils Laboratory now has the capability to complete analyses, including determination of trace elements. An expatriate soil scientist, who has been in charge of the laboratory since September 1984, and is sponsored by the Near East Foundation, supervised the renovation of the facilities, equipment purchases, and the establishment of a program to systematically study the major soil types of Lesotho.

Washington State University conducted an internal review of the FSR Project in January 1985. The purpose of the review was to evaluate accomplishments of the project to date, to determine if modifications in the program were needed, and to identify specific tasks that needed to be done prior to the termination of the project in June 1986. The review was conducted with the consent and cooperation of the USAID Mission and Ministry of Agriculture..

The review team was:

Dr. J.B. Henson, Team Leader	Director of the International Program Development Office, WSU
J.O. Young,	Director, Cooperative Extension, WSU
J.C. Ballard	Consultant, (former Chief-of-Party for the FSR Project)
Wayne Bath	Campus Coordinator, FSR Project, WSU

The team was satisfied with overall progress, and reinforced the Chief-of-Party's plan to concentrate on the activities that were required to bring the project to a successful conclusion. The review took place during the middle of the 1984/85 growing season and one more cropping year remained in the life of the project. The timing and analysis of research trials before the end of the project was recognized as critical. Maize and sorghum, which are normally not harvested until June, were singled out as a particular problem. The reviewers recognized the need to reduce field activities during the last year of the project in order to prepare reports and a written record of accomplishments from the seven years of work in Lesotho. This was evident in the recommendations stated in their report.

1. Research results for the life of the project should be detailed in a 7-year report so that the information is readily available and useful as a part of the total agricultural information base.

2. Production guidelines should be prepared and/or updated in crop production, livestock production, pest management, hortiulture, range and other appropriate commodity disciplinary areas.

3. A slide/tape presentation about the project and division should be prepared as an information transmittal mechanism.

4. Research during the final year should place priority on filling information gaps needed for preparation of production guidelines. A review of each section's and the division's activities should be carried out to define such gaps.

Other priority needs identified by the team included continued support of the Division by the GOL and USAID, the addition of more support staff to provide the labor needed to carry out programs in prototype areas, continued improvements to the Library, upgrading the Soils Laboratory, and holding an end-of-project conference for all relevant individuals and organizations prior to the termination of the project.

The recommedation to the FSR team members to concentrate on closing-down activities was reinforced during a visit to Lesotho by the Campus Coordinator, J. B. Henson, in November 1985.

The executive summary of this section is on pages 42-46. The summary of accomplishments and recommendations is on page 94.

B. Rural Sociology

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B. Rural Sociology

The Rural Sociology Section has not been consistently active throughout the 7 years of the Project. The only expatriate was Lorna Butler during 1979-1981. The program continued on a limited scale under the leadership of Thope Matobo until her departure to WSU for graduate work in 1984, and then resumed under M. Tshabalala in early 1985 until the end of the Project. A personnel shortage has limited the program and hampered continuity throughout the 7 years. However, there were some very significant accomplishments.

The Rural Sociology Section's general goal was:

> " ... to collaborate with the technical units of the Research Division like Range Ecology, Animal Science, Agronomy, Extension and Communication and others to provide them with the necessary information applicable to their programs as the basis of their research in the rural communities. This unit has to keep track of these programs in order that it can advise the technical units concerned and to see how best they can approach the society without running into problems and to give answers to the problems as they may come up. (Matobo, 1982, RD-R-16, p. 41)."

The duties of Rural Sociology personnel are listed in the Project Paper as follows:

1. Analyze available social research results and programs underway for the purpose of assuring such resources are available to and contribute to project purposes.

2. Designs, conducts and analyzes necessary social surveys (socio/economic with economists, socio/technical with agronomists, etc.) to assist in formulating courses of action, training programs and methods of bringing about rural acceptance of technically and economically viable changes in rural enterprise mixes.

3. Advises and counsels project staff on social constraints, alternatives, etc. impinging on acceptance of changes proposed.

4. Consults and coordinates survey research with other social analysts involved in similar activities for other projects and institutions.

1. Baseline Survey

A major contribution to the Project and perhaps the Section's most significant activity was its involvement in the development and implementation of the Baseline Survey. The methodology was published by Butler (1982).

a. Purpose

Butler defined the purpose of the Baseline Survey:

"Establishment of a research and information base which is sensitive to existing farming systems and attitudes demands that some data be collected in the early phases of project implementation. The FSR Project Paper specifies that the project will conduct independent technical, economic and social and subsequent baseline surveys in FSR prototype areas. These areas, designated by the Government of Lesotho in advance of the FSR project's arrival, encompass three ecological regions in which applied research programs are to take place."
More specifically, Butler elaborated six points:

1. To provide a quantifiable description of prototype area farming practices within these interrelated categories: family structure, livestock, range, crops and farmland, farm inputs, marketing, extension and information, and family nutrition.

2. To provide a current description of prototype areas population by describing, on a sample basis, the social structure of area households.

3. To identify social, economic, and technical constraints in increased farm production and income, thereby contributing to future MOA Research Division program directions.

4. To identify better methods of providing agricultural technical information to farmers.

5. To create an on-the-job training laboratory in field survey methodology for Research Division personnel.

6. To increase prototype area farmer involvement in, and understanding of, Farming Systems Research.

A third purpose statement is given in the Research Interviewers' Field Manual, a section of the same publication by Butler (1982):

1. To collect factual information about some of the farmers in Siloe, Nyakosoba, and Molumong areas for a better understanding of their farming methods and problems.

2. To identify ways that farmers can improve their agricultural production and management methods. Farming systems will use this information to develop better farming techniques.

3. To determine what on-the-farm research (tests, experiments) would give greatest immediate benefits to local farmers.

4. To identify better methods of providing new agricultural information to farmers.

5. To improve communications between village farmers and Ministry of Agriculture Research. Research must answer farmers' needs, therefore the people who do research must know what farmers are saying.

b. Methodology (Butler, 1982)

The Data Collection Model. The model had to allow for multidisciplinary collaboration to meet the requirements of the integrated farming systems mandate. Past agricultural projects frequently limited their focus to technical aspects of production, and overlooked the sociological, cognitive, political, and physical constraints to production. The approach had to provide a quantitative basis from which the Research Division could objectively and reliably generalize to comparable farming situations. Lesotho's diverse ecological environment has precipitated a wide variety of farming systems. Limitations of existing data made it extremely risky to make nationwide inferences and predictions.

A basic prototype area household sample was needed from which other samples could later be drawn for more intensive studies. The model also had to provide conventional benchmark data from which to assess changes in household structure, resource availability, technical knowledge, and perceptions of production problems.

Social research skills needed to be strengthened among Research Division staff in order that technical agricultural scientists and social scientists better understand farmers' attitudes, motivations, and behavior with regard to production. A high proportion of Research Division staff had little or no experience in social research design or data collection. Simultaneously, the approach had to be compatible with human resource availability. In the design and implementation phases of the survey there were few people available with the skills needed for application of some methodological designs.

The FSR Baseline Survey was conducted using the personal interview technique and a structured Sesotho language questionnaire. Interviews were conducted with a 14-18% sample of household heads or managers in each prototype area. Data collection was accomplished by establishing a Research Division "trainer team", who in turn trained a different team of village interviewers in each of the three prototype areas. Members of the trainer team, and various research colleagues, assumed specific responsibilities throughout the entire instrument development, data collection, and analysis process. The trainer team collaborated in formulating plans, developing interviewer training courses, and solving intermittent problems. Three MOA Research Division sections took primary responsibility for the survey: Rural Sociology, Marketing, and Extension Information and Communications. The approximate amount of time devoted to major activities is illustrated in Figure III-B-1

Instrument Development. FSR team members from Range, Animal Science, Farm Management, Agronomy, Rural Sociology, and Extension Information and Communications identified the need or a Baseline

Survey in July 1980. Team members developed their own data needs based on existing research findings and their experience to date. The FSR Social Analyst worked with each team member individually to determine how questions should be asked, sequenced, and integrated. During this period the Marketing Economist arrived and his questions were incorportated along with the others. A human nutrition consultant was contracted to work with the Research Division's Nutrition Section to develop a nutrition component for the survey.

Survey Questions. The survey covered seven general subject areas. The questions in each were quite detailed. General subjects with some examples of specific topic areas:

- General Family Description. Who is the head of the household? List members of household, educational level, age, residents, marital status, for each member.

- Livestock. Livestock inventory: types and numbers of animals, livestock problems, feeding, draught animals.

- Crop Production. Land tenure, crops grown, crop problems, fields and field use, production estimates, fallowed fields, seeds and germination, weed control, fertilizers, varieties, pest control, storage.

- Farm Inputs. Labor and labor problems, physical inputs, seed, fertilizer, equipment, ox-drawn or tractor drawn.

- Marketing. Sale of farm produce, marketing problems, prices, which crops sold (maize, sorghum, etc.), animals sold, household income.

- Extension and Communication. Extension agent: do you know him? From whom do you get your information? Radio: do you have one, is it helpful? Preferred sources of information.

- Human Nutrition. Buying and cooking: who makes decisions, food aid (donated food), food as payment, infant feeding (breast-fed?), child's first foods, diet history, sources of nutrition information.

c. Results

Some of the data from the Baseline Survey has been analyzed in the following reports:

Bulletin No.	Author(s)	Title
RD-B-7	T. F. Trail	Communication Channels and Sources of Agricultural Information Utilized by Farmers in the Farming Systems Prototype areas of Siloe, Nyakosoba, and Molumong in Lesotho.
RD-B-11	Earle W. Klosterman	Livestock Production in Siloe, Nyakosoba, and Molumong areas.
RD-B-14	David Holland	Economic Differentiation and Agricultural Commercialization in Three Rural Areas of Lesotho.
RD-B-20	David Holland	Lesotho Agricultural Production: Historical Background and Problems Identified by Farmers in Three Areas in Lesotho.
RD-B-32	Peter W. Wyeth N. Moletsane	Some Survey Evidence on Markets at the Farm Level in Lesotho.

Other analyses are found in various informal reports in the bibliography.

2. The 1981-82 and 1982-83 Reports

a. Village Agricultural Committee Training

The primary function of the committee members was, in a leadership role, to serve as another vehicle for education and information dissemination throughout the village farming community. The results of this work are in five typed/duplicated reports written during 1981-82.

(1) Background

Objective: To determine what kind of people researchers are working with so that decisions could be based on the appropriate level and required needs of the people. Interviews provided a profile of the VAC members.

- Participants. Siloe, 18 men and 17 women; Nyakosoba, 10 men and 25 women; Molumong, 13 men and 10 women.

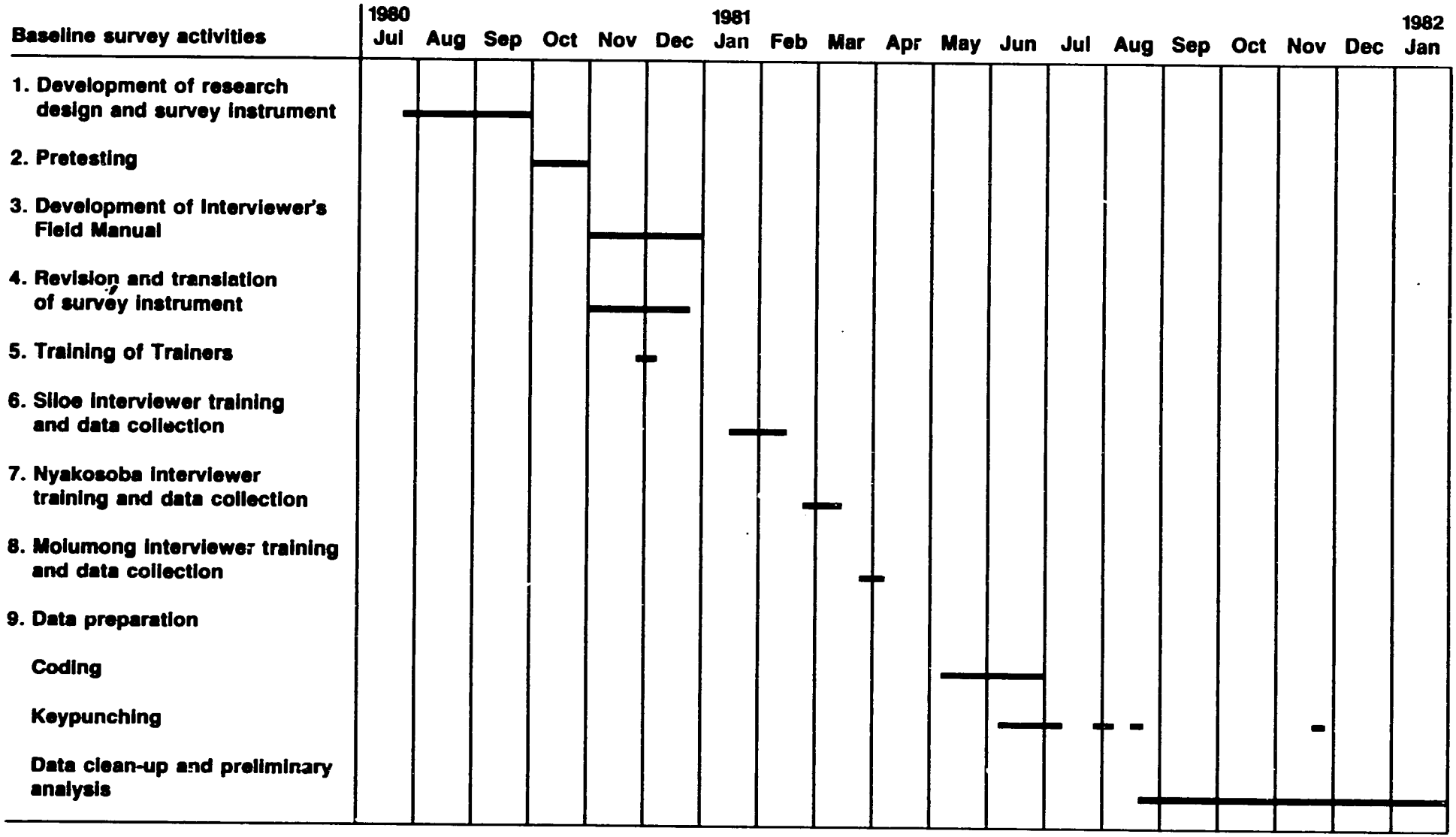

Figure III-B-1. Appropriate timing of FSR Baseline Survey Activities.

- Ages. A majority were in the 40-49 age range.
- Marital Status. More than 70% married, widows were the next largest category. Very few separated, divorced, or unmarried.
- Educational Level. Generally very low. Siloe and Nyakosoba participants, 6-8 years of school; Molumong, 3-5 years.
- Field ownership. A majority owned and managed two or three fields, but many owned only one field.
- Farm equipment. A majority have at least one plow. Some have a plow and planter. Very few have a plow, planter, and cultivator. Some have fields but no equipment.
- Livestock management. A majority manage cattle. Many own poultry. Many own sheep, goats, horses, donkeys, and pigs. At Molumong, more than 50% own sheep, but very few own pigs.
- How do you spend your time? The participants spent most of their time in agriculture-related activities: herding (especially at Molumong), planting, weeding, harvesting (especially at Siloe). Women also spend much time housekeeping.
- What is your task in VAC? Most did not have a clear understanding of this task.

Middle-aged men and women are members of the village agricultural committees in the three prototype areas. Almost all are married and live in the same villages. Only a few spouses live in other areas while searching for work. They return home at certain times, but not necessarily in the plowing, planting, or harvesting season. Their educational level is not very high, but even though they can read and write, they should not be overburdened with written material, but rather demonstrations and verbal communications are better communication techniques.

They have access to land for fields and gardens, which makes it easier for them to practice what they have been taught during the training course. They do not have adequate farm implements although at least one person has a plow, or a planter or a cultivator, which means they can use their farm implements cooperatively to achieve high production. They can even afford to buy inputs.

They have livestock which can be improved by growing and feeding fodder to improve their quality, not quantity and therefore strengthen them for field work.

Apart from livestock, these people have special skills which can help them earn money with which they can buy agricultural inputs to improve their food production. They engage in different occupations in summer and winter although some are not seasonal.

A majority are members of other organizations apart from the VAC, so it is possible that at certain times they will be attending other meetings or activities.

(2) Evaluation of Training of VACs. March-April 1982.

The evaluation was administered to 47 VAC members who attended the July-August 1981 course: 17 in Siloe, 13 in Nyakosoba, and 17 in Molumong. The purpose was to determine if the previous course had any impact: if they had practiced some things they were taught, and whether they now understand their task. It was determined that they now understood their task.

- Organic fertilizer: they were beginning to be aware of the importance of kraal manure, ash, and compost and were using them.

- Inorganic fertilizer: there was more awareness and use, although some still do not use any fertilizer.

- Growing fodder: barley is used by a majority, followed by oats. Very few used lucerne. Others did not grow fodder.

- Recommended crop varieties: Recommended pea and bean varieties were grown. There was a trend toward improved maize varieties. They still planted local sorghum, in Molumong local wheat was still grown, but about half in Siloe and Nyakosoba used improved wheat.

In conclusion, farmers were prepared to spend more money to buy recommended improved seeds in order to improve production. The VAC members will set an example for other farmers, thus passing along agricultural information. It is only if they know what they have grown that they can compare germination, growth, and maturity of each of the varieties they have planted.

- Culling livestock: 20 of 47 started culling, citing four reasons: produce better quality wool and mohair, followed advice given in VAC training, have seen that unimproved livestock is not profitable, and wanted to preserve rangeland for improved livestock. Diffusion is gradually taking place.

- Grazing control regulations: VAC members showed enthusiasm, and formed grazing associations.

- General conclusion: group formations are important and are good channels to convey messages.

(3) VAC's Attitudes on Selected Farming Practices.

VAC members were asked their attitudes about eight different farming practices.

Increase Maize Production. The farming practices listed by most Committee members as important (Table III-B-1) included use of improved varieties (Siloe 65%, Nyakosoba 78%, and Molumong 57%). Another farming practice listed as important was autumn plowing (Siloe 62%, Nyakosoba 39%, and Molumong 43%). Keeping weeds cut until maize has reached the right height was listed as the most important practice by 61% of the participants from Molumong, 38% at Siloe, and 36% at Nyakosoba. Arguments in favor of autumn plowing and keeping weeds cut, are that insect populations are reduced, and tilled soil allows more moisture to soak in. Other arguments for keeping weeds cut are such that weeds compete with crops for nutrients.

Autumn Plowing. Altogether 75% of the participants in all three prototype areas said they plow their fields in the autumn (Table III-B-2). Of those participants who said they do not plow their fields in autumn, a little over half (56%) were women.

The most common reason for now plowing in the autumn was that oxen were not available at this time of the year. Non-availability means that those who do not own oxen cannot afford to also hire them in spring for plowing, owners of oxen cannot spare them at this time of the year because it is cold and they believe that when oxen work hard and sweat they get cold and may die, and oxen are weak and have hardly anything to eat by the time harvest is over.

Fertilizer. One of the major reasons the participants from the three prototype areas did not use commercial fertilizer was that they did not know how to use it (Table III-B-3). For the Siloe and Nykosoba participants, another major reason was that commercial fertilizer costs too much and they do not have the money to pay for it. Lack of transport, which does not seem to be serious problem for these two areas, was the second major reason why most of the Molumong participants said they did not use commercial fertilizer.

Timely Plowing. Generally, the three main practices that the participants listed as important for timely plowing were growing special oxen feed, reserving special pastures to feed oxen, and having stronger oxen (Table III-B-4). These indicate that the major hinderance to timely plowing is oxen unfit for any heavy work in the spring. The participants said that strong, well-fed oxen do their work faster and better than weak, ill-nourished ones. This means that oxen-owners can plow their own fields and still release their oxen for hire. Also, strong oxen can be used at any time of the year, even when grass is scarce.

Grass for Livestock. Very few people from Siloe (5%) and Nyakosoba (14%), said there was enough grass for their livestock. In contrast, 61% of the participants from Molumong thought that the grass was quite adequate for their livestock (Table III-B-5). It is more interesting to note that as altitude increased, more people believed that there was enough grass for the livestock. Each prototype area should be considered individually; what is good for one may not necessarily be good for the others.

Of the participants who said grass was not adequate for their livestock, 49% believed that the problem could be solved by enforcing rules against trespassing in cattle pasture areas. Forty-one percent thought that rotating animals to rest pasture could solve the problem.

Cattle Sales. Participants were asked to list which circumstances would persuade them to sell more of their cattle (Table III-B-6). Most of the participants from Siloe (62%) said shortage of grass fodder would persuade them to sell more cattle, while 64% of the Nyakosoba participants indicated that they would sell more cattle if they needed more money, and 87% of the Molumong participants said higher cattle prices would persuade them to sell more cattle.

Selling Prices. When a buyer has a lot of money and needs maize badly was a situation when many participants, from all three areas, felt they could ask for higher maize prices (Table III-B-7). This situation was picked by 81% of the participants from Siloe, another 81% of the participants from Nyakosoba, and 78% of the participants from Molumong (Table III-B-7). This response is encouraging because it shows that many participants probably had some understanding about the way the market works, and could take an advantage of a monopolistic situation.

Table III-B-1. Percent of VAC members who think selected practices are important to increase maize production.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
Farming practices	F[4]	M[5]	F	M	F	M
Plant earlier	31	6	27	20	30	46
Use seed of improved varieties	65	67	77	80	50	46
Control stockborer	10	39	12	30	0	31
Control cutwork	5	28	15	30	20	8
Plow in autumn	68	61	27	20	40	46
Keep weeds cut until maize is "knee-high"	53	22	62	30	70	54
Use a planter	10	56	12	20	70	54
Use fertilizers	58	22	31	40	50	31
Use seed of high germination	5	0	12	10	10	8
Plant at normal time	-	6	5	5	-	-
Right type of soil	-	6	-	-	-	-

1. Siloe: 19 females and 18 males
2. Nyakosoba: 26 females and 10 males
3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

The other situations which many participants felt would lead them to ask for higher prices for their maize were: when shops are selling mealie meal at a high price; when the village is a long way from shops and the neighbors have no maize to sell, when the individuals concerned and other farmers have a very big maize harvest, and when very much in need of money and a few people want to buy maize. The last two responses indicate that some participants still did not understand marketing. Lectures on marketing highlighted these issues and helped confused participants.

Crop Growing. In general, the three main reasons for growing maize, sorghum, peas, beans, and wheat as listed by participants from their prototype areas are first, to provide food for families, and second and third, either to provide food for animals or to sell or trade. By growing these crops for animal feed, the participants meant that after harvest their animals feed on crop residues, particularly in winter when grass is scarce. In a few cases however, they

Table III-B-2. Reasons listed by VAC members (%) who said they do not plow in the autumn.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
Yes:	68	72	77	80	80	92
No:	32	28	23	20	20	8
Crops still in fields	0	80	33	50	50	0
Need crop residue for fuel	0	0	17	0	0	0
Let the soil regain its fertility from crops	0	80	17	50	0	100
Need to have crop residue for animal grazing	17	0	17	50	0	0
No oxen are available at this time	83	80	83	0	100	100
Not enough labor available	50	20	67	0	100	0
Soil is too hard	67	60	0	50	100	0
It is not a custom, nobody does it	17	0	0	0	50	0
People would be upset to lose the grazing	0	0	0	0	0	0
Winter is the time to rest	0	0	0	0	0	0
It is too cold	0	0	0	50	0	0

1. Siloe: 19 females and 18 males
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4. F = Female
5. M = Male

indicated that when their maize crop is still green, they sometimes cut it, leave it to dry, and finally feed it to their animals. They said they often do this when their maize crops fail.

Figures for participants who said they grow these crops for sale or trade are generally higher for peas/beans and wheat as compared to figures for maize and sorghum. This difference may mean that peas, beans and wheat are better cash crops than the other two crops. Table III-B-8 shows the results on each crop.

(4) Training VACs: Value Study

The purpose of the value test was to help both the Research Division staff and FSR colleagues to better understand the

Table III-B-3. Reasons listed by VAC members (%) for not using commercial fertilizer.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
Yes:	5	50	19	20	20	4
No:	95	50	81	80	80	96
It is not available	28	11	48	25	0	37
It costs too much, I have no money	56	78	62	75	50	50
I have no transport	39	11	33	38	63	63
I do not know how to use it	89	67	62	50	75	87
It will decrease my yield	0	0	0	13	0	0
If I use it once I will have to use it forever	28	33	24	13	50	25
It does not pay	0	0	0	25	0	0
It is not the custom, nobody does it	39	33	33	25	50	38
I believe that kraal manure is enough	-	11	10	-	-	-
I never knew that field soil needed fertilizer	-	-	5	-	-	-
It is not necessary	-	-	-	13	-	-

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3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

participants' general attitudes. These values may affect their attitudes or behavior towards agriculture. Knowledge of values would also facilitate communication between Research Divison staff and farmers. Instrumental values are listed in Table III-B-9, and terminal values in Table III-B-10

Of the instrumental values, Ambitious was first priority in Siloe, and second priority in Nyakosoba.

Intelligent also got a high score either as first or second priority in the three areas. To Own Much Livestock scored as the least important priority in the three areas. The rest of values were evenly distributed.

Of the terminal values, Salvation got the highest priority in all three prototype areas. It was followed by Wisdom in both Nyakosoba and Siloe areas. A Comfortable Life scored as the least important priority in this set of values, the rest the values were evenly distributed.

Table III-B-4. Practices listed by VAC members (%) advantageous to timely plowing.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
Do more sharecropping	12	33	23	30	10	31
Do more letsema	12	39	19	10	10	23
Grow special oxen feed	68	50	77	80	60	69
Do more "kopanelo"	53	44	38	70	30	46
Have more oxen by "Mafisa"	5	0	4	10	0	15
Reserve special pasture to feed oxen	63	50	50	20	70	62
Decrease total number of livestock so your oxen can get more to eat	12	17	4	40	10	8
Cooperate with other farmers to feed oxen, then rent them	5	22	31	20	10	8
Have stronger oxen	63	44	50	50	70	31

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2. Nyakosoba: 26 females and 10 males
3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

(5) Evaluation of the Village Agricultural Committes March - April 1982

An evaluation was administered to all participants in the second VAC course. This evaluation was very short.

The first question asked if the discussions on the reponsibility of Village Agricultural Committees were helpful to all of them. They had to explain their helpfulness, or explain why they were not helpful. In the three prototype areas, all said that the discussions were helpful.

Table III-B-5. Possible solutions listed by VAC members (%) to solve problm of inadequate pasture for livestock.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
Grass adequacy Yes:	0	11	12	20	50	62
No:	100	89	88	80	50	38
At cattle post, limit number of grazing permits issued	0	0	4	13	0	13
At cattle post, rotate animals to rest grass	21	38	30	50	0	38
At cattle post, enforce rules against trespassing	53	63	52	38	100	13
At village, limit number of grazing permits issued	26	31	9	0	40	25
At village, rotate animals to rest grass	63	44	43	38	0	13
At village, enforce rules against trespassing	63	44	35	0	40	13
Get access to cattle post range	26	31	35	50	40	25
Buy fodder for animals	16	19	48	50	0	0
Do not let owners of animals increase herd size	53	63	17	38	40	13
Reduce number of animals owned by culling old or inferior stock	32	38	13	25	40	38
Grow fodder for animals	-	6	4	-	-	-

1. Siloe: 19 females and 18 males
2. Nyakosoba: 26 females and 10 males
3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

According to the VAC members, these discussions clarified some points that were not clear to some, especially those who did not attend the earlier training course where their responsibilites were discussed at great length. These discussions helped them to share ideas about how to solve agricultural and social problems they encounter when acting as Village Agricultural Committees. They believe in group discussions.

Another question asked if the Agronomy topics were clear. In the Nyakosoba and Molumong prototype areas the participants said that everying was clear. At Siloe very few people said the topics were not clear.

The participants were asked if they either read or follow the practices on the instructions on pesticides. This question was asked in order to find out if they can read and understand the instructions. Fifty-six percent of the participants said they could easily read and use the insecticides. Others said they can only use insecticides if somebody read the instructions. Very few, about 6%, said it is easier to read the instructions than to use the chemicals.

They were asked if there was something in horticulture that they expected to learn but were not taught. The majority were satisfied with what they were taught. Some had expected to be taught about potato production and growing carrots, radishes, spinach, and beetroot, but they were not.

Table III-B-6. Circumstances that may persuade VAC members (%) to sell cattle.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
Shortage of grass fodder	68	56	46	60	100	15
The need for money	48	78	73	50	50	77
Higher cattle prices	47	50	46	50	100	85
Lower cattle prices	16	22	4	10	0	0
A reliable local market	5	33	27	50	10	31
Having many old animals	58	50	65	40	20	31
Having no herder	63	11	35	40	20	38
If your neighbors are selling	0	11	0	0	0	0

1. Siloe: 19 females and 18 males
2. Nyakosoba: 26 females and 10 males
3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

b. Using Horses as Draft Animals (Thope Matobo, 1982)

The objective was to investigate the sociological problems encountered when disseminating the idea of using horses as draft animals.

It was not a question of feasibility. Two projects had already established the advantages of using horses over oxen. It had been demonstrated that horses were stronger, faster, more durable, and easier to feed, resulting in significantly greater efficiency.

The Rural Sociology Section visited two projects that are now actively involved in using horses as draft animals, the Iberman Project in the Mafeteng District, and the Rural Technology Unit of the Thaba Tseka Project.

Table III-B-7. Circumstances listed by VAC members (%) which can lead to higher prices.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
You and other farmers in your area have a very big harvest	68	67	54	50	20	38
The buyer has a lot of money and needs maize badly	68	83	77	90	70	85
The shops are selling mealie meal at a high price	58	67	62	50	60	46
Other farmers are selling maize at a low price	11	11	15	10	40	31
Your village is a long way from any shops and your neighbors have no maize to sell	47	39	54	60	30	46
You are very much in need of money and few people want to buy maize	47	33	35	40	80	62
When the need to make a profit requires	-	-	8	-	-	-

1. Siloe: 19 females and 18 males
2. Nyakosoba: 26 females and 10 males
3. Molumong: 10 females and 13 males
4. F = Female
5. M = Male

Table III-B-8. Reasons listed by VAC members (%) for growing crops.

	Siloe[1]		Nyakosoba[2]		Molumong[3]	
	F[4]	M[5]	F	M	F	M
			Maize			
Yes	100	100	100	100	80	85
No	0	0	0	0	20	15
To provide food for family	100	100	100	80	70	100
To provide food for animals	63	83	81	70	60	91
It is a custom, everybody does 16	33	12	20	10	27	
So I will not lose my fields	42	22	19	20	20	9
To make beer	0	6	12	0	0	9
To sell or trade	74	56	73	50	50	64
			Sorghum			
Yes	100	100	77	80	60	69
No	0	0	23	20	40	31
To provide food for family	95	100	100	75	100	89
To provide food for animals	68	72	60	50	50	78
It is a custom, everybody does 16	28	10	13	33	44	
So I will not lose my fields	32	28	15	13	17	22
To make beer	5	33	45	38	33	11
To sell or trade	79	39	65	50	67	56
			Beans & Peas			
Yes	100	100	100	100	100	100
No	0	0	0	0	0	0
To provide food for family	95	89	100	80	100	100
To provide food for animals	58	50	69	60	50	85
It is a custom, everybody does 26	39	23	20	20	46	
So I will not lose my fields	26	28	12	10	40	0
To sell or trade	89	78	85	70	90	77
			Wheat			
Yes	89	94	96	79	80	92
No	11	6	4	30	20	8
To provide food for family	88	83	96	100	100	92
To provide food for animals	65	67	88	100	50	75
It is a custom, everybody does	24	50	4	14	13	33
So I will not lose my fields	24	17	12	0	38	17
To make beer	0	11	4	0	25	0
To sell or trade	94	56	84	86	75	75

1. Siloe: 19 females and 18 males. 2. Nyakosoba: 26 females and 10 males. 3. Molumong: 10 females and 13 males. 4. F = Female. 5. M = Male.

Table III-B-9. Instrumental values.

English	Sesotho translation
1. Ambitious Hardworking	Ho ba sepheo Ho sebetsa ka thata
2. Broadminded Open to new ideas	Ho ba chatsi Ho amohela maikutlo a macha
3. Capable Competent, skillful	Ho ba sechlahlo Ho its'epa; ho itsebela
4. Influential Speaker to speak convincingly	Mosusumetsi (Ho bua ka ts'usumetso le bokhele)
5. Forgiving Willing to pardon others	Ho tseba ho ts'oarela Ho ikemisetsa ho ts'oarela ba bang
6. Helpful working for the welfare of others	Ho ka thusa, Ho ba le thuso Ho sebetsa molemong oa ba bang
7. Honest truthful	Bots'epehi Ho ts'epahala; hoba le nnete
8. Imaginative to do things in new ways	Ho ikamahanya le liphetoho Ho intlafatan; Ho sevelisa mekhoa e mecha
9. Independent Self-reliant; self-sufficient	Boits'ep Ho ikhoan; Ho itekanya
10. Intelligent reflective	Ho ba le kelello; bohalale Ho ka nahana le ho sevelisa hollho
11. To share equally to share what you have with others	Ho arola ka tekano Ho arola ka tekano
12. Obedient always do what others ask	Ho hlonepha Ho phethahatsa likopo tsa ba bang
13. Polite well mannered	Ho ikokobetsa Ho ba mekhoa e metle
14. Reliable dependable	Ho ts'epahala Motho eo o ka its'etlehang ka eena
15. To travel widely to know many places	Ho eta haholo Ho tseva libaka tse ngata

Table III-B-9 (Cont'd)

16. To own much livestock	Ho rua phiphitha ea mehlape
17. To produce many crops High production	Ho chaea Chai
18. Generosity to give many feasts, gifts and hospitality	Phano Ho etsa mekete, ho fana, kamohelo e mofuthu ho baeti
19. Cooperative to work with others	Boikopanyo ts'evelisano 'moho
20. Conformity to be the same as others	Kamohelo Ho se ikhetholle
21. Logical rational	Ho tseba ho lokolisa Ho tseba ho hlalohanya; ho rera
22. Self-control Self-discipline	Boitaolo Ho tseba ho itaoloa; Ho laola maikutlo a hao
23. Cheerful good humored	Ho thaba Ho ba mosa
24. Membership in many organizations/groups	Ho ba setho sa mekhatlo e mengata

In both cases, the project workers were enthusiastic about the idea, but what needed to be answered was how the idea affects tradition or the "prestige" of using horses for riding. The interview method was used, both for project workers and village farmers, especially those who had begun replacing oxen with horses.

Social prestige was not much of a detriment to the use of horses for draft power. It "does not lower the prestige of the owners, instead it increases his status in society as he can complete work in his fields quickly ... he is honored for that". "Farmers no longer think about prestige but about their stomachs."

In short, "it is not very difficult to get the farmers who have horses to use them in field activities if a trainer is available."

c. Rotation Grazing, Nyakososba/Ha 'Mokele, July 1981

The village of Ha 'Mokele is on the northern side of Nyakosoba prototype area. It has 27 households and 13 livestock owners, 151 sheep, 90 cattle, 19 horses, 151 goats and 25 donkeys. In 1973, a village grazing rotational system was started to demonstrate the importance of controlled grazing.

Table III-B-10. Terminal values.

A. Happiness to be content	Thabo Ho thaba; Ho khotsofala
B. True friendship To have someone to share with, or someone to depend on	Setsoalle sa nntete Motsoalle oa hlooho ea khomo
C. A sense of accomplishment to feel you have achieved something that will be remembered	Ts'ibollo Ho phethabatsa se ke keng sa lebaloa
D. A village at peace a community without conflicts or quarrles	Motse oa Khotso Sechaba se se nang likhang le likhohlano
E. A rich natural environment fertile soil, plenty of grass and trees, adequate moisture	Tikoloho e manoni Mobu o nonneng, joang bo bongata le lifate mongobo o lekaneng
F. Equality equal opportunity for everyone	Tekano Menyet la e lekanang ho bohle
G. Family security taking care of loved ones	Ts'ireletso ea lelapa Tlhokome oa bararuoa lelapa
H. Freedom free choice	Tokoloho khetho e lokolohileng
I. A comfortable life a prosperous life	Boiketlo Katleho bophelong; borui
J. Inner harmony freedom from personal guilt or anxiety	Tlhaboloho Ho se ngongorehe. Ho hloka makukuno moeeng
K. Pleasure An enjoyable life	Monyaka Bophelo bo khahlehang; bo thabelehang
L. Self respect to feel good about yourself	Boitlhompho Boitlhompho metsamaong; ho ithata
M. Respect and admiration of others	Thlomepho le chebeho Ho hlonepha ba bang le ho khahloa ke bona
N. An exciting life a life that is not dull	Bophelo bo mafolofolu/morolo Bophelo bo seng bolutu; bo seng bosula

Table III-B-10 (Cont'd)

O. Wisdom Bohlale; knowledge of life	Phalimeho tsebo ea bophelo
P. Salvation eternal life	Pholoho Bophe bo sa feleng; Leholimo
Q. Peace with ancestors	Khotso le Balimo
R. Deep love to have someone care very much about you	Lerato le tebileng Ho ba le motho ea o khathallang ca ka iketsang sehlabelo molemong oa hao

This report expresses the views of villagers, the acting area chief, and a neighboring headman. Data collection involved both group discussions and individual contacts by the Rural Sociology Section and MOA.

Three decisions needed to be made: where to close/open grazing and for how long, when to send animals to the cattle post, and who has to be expected to graze in closed areas. Decisions on closing/opening are based on the conditions of the grass and the season.

Most farmers send their animals to cattle posts from October to December. After the livestock owners meeting there is an announcement of the last date when all animals must go to cattle posts. The rotation is strictly practiced from December to August, but September to November are free grazing months. It was observed that sheep spoil the grazing by not eating tall grass, but trample it.

Certain types of animals were exempted from grazing rules: draft animals working in a closed area, and breeding ewes grazing on the owner's fodder field within a closed area, but the farmer in question need to obtain permission from the "caretaker." Grazing would be allowed on the working or fodder field plus the access to the field. No exemption is given to graze on fallow fields.

Grazing is shared back and forth with all neighboring villages. These are all under one Area Chief (Ha 'Mokele inclusive). Sharing is based on neighborhood, Area Chief jurisdiction, and crop production/farming pattern, i.e., farmers having fields in village areas other than their own village area. Most field work is done with animals and they have to graze before and after the field work. 'Mokele people are happy with this system because there is always an area reserved for spring grazing, which is a critical time to condition draft animals. Secondly, there is flexibility for animals to roam about when total grazing deteriorates. In general, 'Mokele people are happy and ready to cooperate in the new system. There was oppostition by one farmer and two headmen.

Summary and Recommendations. Rotation and grazing control is 8 years old in this village. Farmers have some experience, and it is important to take advantage of this experience. Their opinion would be important when developing the grazing and rotation pattern.

There is a lot of democratic cooperation within the village which should be encouraged so farmers are able to solve their problems. During data collection there were concerns about certain problems, which the villages thought were for the MOA to solve. But the Research Division staff pointed out these problems were for them to solve. Range and Extension staff should keep in close contact with 'Mokele village to understand the nature of the problems and act in time to help resolve them.

The new rotational grazing system was started in one of the smallest villages in the prototype area. Larger villages developed some jealousies. Consideration was given to expanding the program to include all villages under one Area Headman. 'Mokele has enjoyed sharing rights with its neighbors, but the 'Mokhele grazing area is not sufficient to cater to their animals only through the year. Range and Extension needed to start an intensive education program in neighboring villages about range rotation to help solve grudges and jealously problems from other villages.

There needs to be a record system of all activities by the Research staff, such as meetings held and discussion topics, peoples views and attitudes, rotation dates, and livestock movements into various camps, etc.

In an evaluation a year later in July 1982, livestock owners were asked if the program was successful, and what were some of the problems. In general livestock owners thought the program was successful, although some had reservations.

The executive summary of this section is on pages 46-52. The summary of accomplishments and recommendations is on page 95.

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C. Farm Management

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C. Farm Management

1. The Agricultural Setting in Lesotho

Agricultural development in Lesotho today is influenced by the culture and traditions of the Basotho, as well as Lesotho's unique position and relationship to South Africa. Crop farming in Lesotho is characterized mainly by small (2-3 ha) subsistence farms. Very little crop production is sold. In the prototype research areas, for field crops such as maize, about 3% of total crop production is sold (Holland, 1983, RD-B-14, p.25). Agricultural productivity (both labor and land) is low.

The reasons for this pattern of development and the lack of commercialization are briefly addressed. A major reason is the relatively small amount of good crop land in Lesotho. The nation of Lesotho grew out of a stand-off in the conflict between the Basotho and the Boers. When the borders were drawn the boundaries of Lesotho included mainly mountainous regions without high quality farm land. The mountains of Lesotho do include some excellent rangeland. The livestock sector, especially sheep and goats is the most commercialized part of Lesotho's agriculture.

Other major factors explaining the lack of agricultural commercialization in Lesotho are the joint effects from its economic relationship with South Africa and its tradition of land holding and land allocation. Farm land is not alienable in Lesotho. The "owner" has only usufruct rights that are conditional upon approved use. Usufruct rights mean the landholder does not own the land. Subject to certain conditions he/she may use the land and own what is produced from it. The right to use a field was traditionally allocated by the local chief.

Each family was to be given enough land to provide for its basic food needs. As a result, there is relatively little differentiation, in comparison to countries with a private market for land, in access to farm land in Lesotho. The land institutions in Lesotho have effectively preserved the integrity of Lesotho by preventing outside ownership of Lesotho farm land, and have allowed most rural Basotho families to have some claim to agricultural production. These same institutions have resulted in land ownership by many families who have neither the capital, labor, knowledge, or interest to farm in a commercial manner. This lack of incentives to commercial farming is to a large degree the result of the relationship to the South African ecomomy.

For families who do have land, the most common size holdings are either one, two, or three fields. Ownership of more than three fields is relatively rare. In the prototype areas, families who own more than three fields, control 23% of the land and account for 6% of the families (Holland, 1983, RD-B-14). Approximately 25% of the families do not own land. Land in Lesotho has not functioned as a store of

value, has not been a mechanism for the creation and extension of bank credit, and has not been a driving force in the commercialization of agriculture as it has in other countries with different land institutions.

There has been no direct financial incentive to accumulate large land holdings, and in fact the traditional land allocation system made such accumulation very difficult. With few fields scattered over a wide geographic area, the financial pay-off to traditional crop agriculture has been small relative to the main alternative, working for wages in South Africa. Lesotho's land institutions have been a very important factor in shaping the agricultural development path.

Historically, Lesotho has seen a transition in its economic relations with South Africa. At the time of the opening of the diamond and gold mines in South Africa in the 19th century, Lesotho was an important supplier of not only labor to the mines, but also of wheat to South African markets. By the 1930s that relationship had permanently changed. Lesotho was supplying only labor to South Africa, and South Africa was now supplying increasing quantities of food grains to Lesotho. The reasons for this are found partially in the industrial and agricultural policies of South Africa, and partially in the agricultural traditions and policies of Lesotho.

South Africa used economic surpluses from the mines to promote its own agricultural development through agricultural research and extension, while at the same time instituting protectionist policies blocking the expansion of agricultural imports from its neighbors. Imports of labor from Lesotho and surrounding African countries, on the other hand, were welcomed and were an important element in helping to augment the supply of black labor in South Africa.

What confronted Lesotho was a situation in which labor was supplied to South Africa, but none of the resulting economic surplus came back to Lesotho. Instead, that surplus was used in South Africa to help consolidate white control of resources, and to develop the agricultural and industrial infrastructure of South Africa. The South African agriculture became commercialized while Lesotho with it's land holding tradition and with no economic surplus to help develop its agriculture, retained its subsistence agriculture, and became increasingly dependent upon the sale of its labor to South Africa as its population expanded on a limited and fixed land base. Apartheid laws were important in defining this response. This development pattern suited the needs of the South African economy because even below-subsistence wages could be paid to labor in the mines. Agriculture in Lesotho and other peripheral countries was used by the resident population to supplement mine wages. At the same time the increased dependency by Lesotho households upon South African income meant that an important market for agricultural and industrial commodities from South Africa could be secured in Lesotho.

The importance of reviewing and understanding the historical development of Lesotho's agriculture lies in its implications for farm management research.

2. The 1980–82 Period

Dr. Joel Plath was the farm management economist on the project during 1980-82. The bulk of his work is reported in six publications.

a. Farm Management Research in the 1970s - A Bibliography. (Plath, 1982, RD-B-2)

This bibliography focuses on research reports that describe farming practices in Lesotho, the use of labor and land, and the economics of farming in the country. Most of the 27 reports describe farming practices, report yields for that particular year, and some report livestock management practices. Of the 27 cited, 18 deal with crops, 6 with livestock, and 3 are general. Four of the reports cited are not associated with a particular project. Projects that have reports included in the bibliography are the Thaba Tseka Mountain Development Project (3), the Thaba Bosiu Rural Development Project (8), the Senqu River Agricultural Extension Project (3), an FAO Pilot Agricultural Scheme in the Leribe Area (1), the Khomokhoana Rural Development Project (6), the Phuthiatsana Irrigation Project (1), and the Thaba Phutsoa Irrigation Project (1).

Most of the farm management research was conducted in the lowlands and foothills regions with crops. The work reported in the 27 publications was almost entirely conducted during the 1970s.

In-depth research into livestock and livestock/crop mixes was not reported, or at least was not found by Plath, and little work had been done in the mountains of Lesotho. There is a need to provide data on detailed disciplines and enterprise budgets for the entire country, perhaps with some emphasis on livestock enterprises in the foothills and mountain regions.

b. Selection and Characteristics of Participants in Farm Research Program, 1980/81. (Plath et al., 1981, RD-R-1).

A farm records program was initiated in September 1980 in the three prototype areas (PAs) of the Farming Systems Research Project. A total of 120 farmers were selected to participate in the progam, 60 in the Siloe PA, and 30 each in the Nyakosoba and Molumong PAs.

The farm records program was a means of collecting detailed information from farmers in the PAs on the resources they had available and on how those resources were managed to produce food and fiber. The reasons for collecting this information were: 1) to describe and analyze the farming systems being used; 2) identify major constraints faced by the farmers; and 3) identify practices used by the more productive farmers that could be recommended to, and adopted by, the less productive farmers. Field assistance required to

visit participating farmers every two weeks was provided by employing a Farm Management Research Assistant (FMRA) in each PA (two in the Siloe PA).

Farmer participants were selected according to criteria determined to be appropriate from previous studies of rural household characteristics and census data. The criteria used to select farmers to participate in the record-keeping program were:

- Must be willing to participate; they must be willing to work with you, and you with them.

- Geographic location. Within a prototype area (PA); it should not be too much of a burden to visit them on a regular basis; but all participants should not be concentrated in one area or in only a couple of villages.

- Land and livestock characteristics:

  --an average of 2 fields per family/household

  --each household must have access to the production of fields and make the production decisions for those fields (the fields must be allocated to the household or used by the household under a sharecropping or other arrangement).

  --between 35% and 45% of the farmer participants should have land but no livestock

  --about half (65% in Molumong) to have both fields and livestock.

- Household characteristics:

  --average household size: about 5 people

  --about 25% of the households should be headed by a woman

  --of those headed by a man, about 30% of them (20-25% of the total) should be absent from the farm (working elsewhere in Lesotho or in the Republic).

  --age of household/manager: about 35% under 45 (with some under 35); about 45% between 45 and 65; reminder (20%) over 65.

A survey was conducted of farmers in the PAs to identify those who met the predetermined criteria. A questionnaire was completed for each farmer willing to participate in the records program. The questionnaire contained questions relating to the target characteristics discussed above (willingness to participate was evidenced by their willingness to respond to the questionnaire and geographic location was determined by the FMRA). The responses to the questionnaire allowed the set of farmers willing to participate to be stratified. The subset of 30 farmers who would actually participate could then be selected so that, as a group, they would have characteristics similar to those targeted. The questionnaire used is shown below.

QUESTIONNAIRE
Potential Farm Records Participants

Name: Prototype Area: S N M

Village:

1. How many people are in your household? _____

2. The head of your household is (circle): Male Female ?

3. (a) Does the head of your household have a job which requires him/her to live away from home much of the year? (circle) Yes No
   (b) If Yes, the person who manages your household in his/her absence is (circle): Male Female ?

4. What is the age of the household head (or if he/she is often absent, the person who manages your household)? _____

5. (a) How many fields have been allocated to members of your household? _____
   (b) If None, do members of your household farm fields allocated to others? (circle) Yes No
   (c) If Yes, who decides what will be grown on those fields and how it will be grown? (circle) Household member Other

6. (a) Do members of your household own livestock (cattle, sheep, goats, horses)? (Circle) Yes No

   If Yes (b) Number of cattle _____
   (c) Number of sheep _____
   (d) Number of goats _____
   (e) Number of horses _____

7. What crops do you plan on growing this season? (tick those indicated)

   (a) Maize
   (b) Sorghum
   (c) Wheat
   (d) Beans
   (e) Peas
   (f) Maize and Beans together
   (g) Other (specify) _____
   (h) Other (specify) _____
   (i) Other (specify) _____

The characteristics of the farmers participating in the 1980-81 farm records program are presented in Table III-C-1. Thirty were originally selected in the Nyakosoba PA, but two were withdrawn when they became concerned that the reason the information was being collected was to enable the government to take away their land.

Males were cited as head of the household for 75% of the households. However, of those males, 32% had jobs that required them to live away from home much of the year. In their absence, their households were managed by women. Approximately 51% of the households were headed by a male who was present and the remaining 49% were either headed or managed by a woman. The average age of the household head or manager was 51 years. Approximately 35% were 45 or younger, 47% between 45 and 65, and the remaining 18% were over 65 years old. Household characteristics were quite close to the targets.

Each household had an average of 2.2 fields allocated to it, with a range of 1.8 in Nyakosoba to 2.3 in Molumong. Almost all fields were to be allocated to grow crops for human consumption. Maize was to be grown by the majority of farmers in all three prototype areas (50% in Siloe South, but over 86% in Siloe North, for an average of over 68%). The intention to grow sorghum decreased from the lowlands (Siloe) to the foothills (Nyakosoba) to the mountains (Molumong). Conversely, the intention to grow wheat and peas increased as altitude increased. The intentions to grow beans or maize and beans together did not show a clear trend as altitude changed. These cropping intentions were as expected given the geographic location of the prototype areas.

The incidence of livestock ownership increased from Siloe to Nyakosoba to Molumong. This was expected given the comparative advantages of the three PAs (in terms of availability of rangeland). There was no obvious explanation for the relatively low ownership of sheep and goats in the Nyakosoba PA.

The need to know how well a study such as this deals with a representative sample of the population in question was expressed by Plath.

"It is apparent that the FMRAs were quite successful in selecting participant farmers who, as groups, came close to the target characteristics. Unfortunately, at this time there are no other data sources from the three prototype areas with which to test the representativeness of these farmers. It is hoped that when the results of the baseline survey are compiled, (the baseline survey is currently being conducted on a random sample of households in each of the prototype areas), the characteristics of these households will be shown to be representative."

Plath and his co-workers acknowledged that farmers participating in a farm records program are frequently more "progressive" than their neighbors. Also, they were not selected in a random manner and it could not be assumed that they were necessarily representative of the farmers in each prototype area. However, it was hoped that they would be representative of various types of farmer households in the PAs. The "sample" was further biased by including some "non-representative" farmers, namely chiefs and relatives of chiefs. They were included to ensure their goodwill even though they generally had more fields and livestock than other farmers. This tended to increase the "average" number of fields, livestock and other resources owned by farmers in the area.

This information-gathering process relied heavily upon the willingness of the farmers to be candid in responding to questions. "Consequently, it has already been found that some of the participants provided an answer to some questions initially and provided a different response later. The incidence of this increases as the queries become more personal (e.g., the number of fields allocated and the number of livestock owned by the households). Where it is possible, checks are made and discrepancies investigated. Ultimately, we must rely upon the goodwill of the participating farmers. It is critical, therefore, that their trust be gained and maintained," Plath reported.

c. Farmers' Control of Resources in the Three Prototype Areas. (Plath 1982, RD-B-1).

Farmers' ability to produce agricultural goods is determined by their ability to use the necessary resources. These resources are frequently classified as land, labor, and capital. They are critical in agricultural production and a farmer's access to them (or lack of access) helps determine farming activities, what techniques are used, and the timing of the farm operations. Thus, access, or lack of access, to these resouces helps determine the constraints under which the farmer operates and what opportunities are available to the farmer.

Information about resources available to and controlled by them was collected from farmers participating in the farm records program during the 1980-81 growing season (Plath et al., 1981). The resources were: family or household labor, livestock (owned and acquired through mafisa), owned equipment and tools, and land allocated to the farmers or being used under a share-cropping agreement. One resource not considered was cash or money, not because of the unimportance of the resource, but rather because of the difficulty in obtaining this type of information from farmers. Part of the data collected from the survey are shown in Tables III-C-2 to III-C-9.

The major finding of this study was that many of the participating farmers own or control very few of the agricultural resources for which data were collected.

Land. Most of the farmers controlled enough land that if average yields were obtained from all of it they could be self-sufficient in the basic foods (maize, sorghum, wheat, beans, and peas). This result was biased in that only rural residents who control or manage land were included in the farm records program.

The distance of fields from farmers' homes and between fields operated by the same farmer could be a constraint to good crop management practices. The distance between fields, however, could reduce the risk of complete crop failure due to unfavorable weather since the farmers have a practice of planting two or three crops in a particular field and the same crops in all fields. A constraint to

Table III-C-1. Characteristics of farmer participants, 1980-81 farm records program.

Characteristic	Siloe South	Siloe North	Nyako-soba	Molu-mong	Total	Target
Number of households	30	30	28	30	118	120
Avg. number of people in household	5.4	5.0	5.3	5.4	5.3	5
Sex of household head: (%)						
(a) Male	77	67	75	80	75	75
(b) Female	23	33	25	20	25	25
Does household head have a job that requires absence? (%)						
(a) Yes	27	23	43	37	32	NA
(b) No	73	77	57	63	68	NA
If yes, sex of manager (%)						
(a) Male	0	0	0	0	0	NA
(b) Female	100	100	100	100	100	NA
Avg age of head or manager:	51.2	55.2	48.1	49.5	51.0	NA
Avg number of field allocated to the household:	2.2	2.2	1.8	2.3	2.2	2
Does household own livestock? (%)						
(a) Yes	57.0	66.7	68.0	90.0	70.3	55-65
(b) No	43.0	33.3	32.0	10.0	29.7	35-45
If yes, average number of:						
(a) Cattle	3.2	2.5	2.6	13.0	5.4	NA
(b) Sheep	10.4	2.2	2.3	45.9	15.4	NA
(c) Goats	65.	6.4	1.2	19.1	8.4	NA
(d) Horses	0.3	0.4	0.6	3.1	1.1	NA
Planting intentions: (% of households)						
(a) Maize	50.0	86.7	89.0	93.3	79.6	NA
(b) Sorghum	80.0	100.0	50.0	36.7	67.0	NA
(c) Wheat	6.6	0.0	32.0	76.7	28.8	NA
(d) Beans	37.0	26.7	4.0	43.3	28.0	NA
(e) Peas	0.0	3.0	32.0	53.3	22.0	NA
(f) Maize and beans together	33.0	0.0	4.0	26.7	16.1	NA
Age of household head or manager: (%)						
(a) Under 45	35	20	50	40	35	35
(b) 45-65	45	60	32	47	47	45
(c) Over 65	20	20	18	13	18	20

Source: Plath, 1981, RD-R-1.

the use of water-based pesticides is the distance of most fields from a water source.

Labor. Adult male labor does not appear to be a major constraint to most of the participating farmers. This conclusion is the result of a comparison of the adult male labor-land ratio of these farmers with the calculations made in an earlier study (Wykstra, 1978).

One possible constraint is the decision-making abilities of the households. Between 55 and 68% of the households are either headed by women or managed by women in the absence of the male head. If these women do not have the necessary knowledge and experience, or if the absent male heads do not give them the authority, the result could be inferior decision-making on the management of the available resources.

Table III-C-2. Farmer characteristics, 1980-81 farm records program.

	District		
	Maseru	Mafeteng[1]	Mokhotlong
Household size (average)	4.5	4.9	4.7
Household heads			
Male (%)	75.2	69.2	77.9
Female (%)	24.8	30.8	22.1
Absent male heads (%)	26.1	27.4	24.9
Age of household heads			
Under 45 (%)	34.4	27.1	42.0
45-65 (%)	43.8	52.9	40.7
Over 65 (%)	21.8	20.1	17.4
Farming households			
With land, no livestock (%)	43.9	43.7	34.9
With land and livestock (%)	55.3	55.6	63.7
Fields per household (average)	2.2	2.2	2.2
Land area per household (ha)	1.9	2.5	1.5

1. Mafeteng District data were used to represent Siloe, even though Siloe is in Mohale's Hoek District. This was because of Siloe's relative proximity to Mafeteng.

Source: Plath, 1982, RD-B-1.

Livestock. Data were not collected on the draft animals managed by the participating farmers, but some estimates were made. Spans were usually at least four oxen, yet roughly two-thirds of the participating farmers in Siloe and Nyakosoba managed less than four cattle. In Molumong, 72% managed at least four cattle, with a lower percentage managing four oxen. The obvious conclusion is that many of the farmers had to rely upon others for their draft power needs, either by pooling (combining the draft animals of two or more farmers to form a span) or by making some arrangement (hiring, sharecropping, trading draft power for labor, etc.). Many farmers likely wait until animals become available. Their plowing and planting could then be hurried and late, resulting in lower yields.

Sheep and goats are potential sources of cash income to farmers through the sale of wool and mohair. Yet the majority of farmers in Siloe and Nyakosoba do not manage these animals, and for those who do the flock sizes are generally small. In Molumong, most farmers manage sheep and goats, but again the flock sizes are frequently small.

Table III-C-3. Incidence of off-farm residence of household members, 1980-81 farm records program.

	Siloe	Nyakosoba	Molumong	Average
% of household members residing with the household				
1-3 months	15.7	23.1	4.7	13.5
4-6 months	0.6	1.0	11.9	4.1
10-11 months	0.0	0.0	0.0	0.0
All year	83.7	75.9	83.4	82.3
Those who reside away more than 6 months				
Average age	26.0	30.6	26.1	27.1
Male (%)	81.5	80.0	65.6	76.6
Average age	26.9	33.8	32.5	30.0
Female (%)	18.5	20.0	34.4	23.4
Average age	33.1	18.0	13.8	22.0
Household with at least one adult working away (%)[1]	61.7	46.4	44.8	53.8
Households with more than one adult working away (%)[1]	16.7	14.3	20.7	17.1

1. Working away means the adult is away from the household at least 6 months of the year.

Source: Plath, 1982, RD-B-1.

Equipment and Tools. Most of the farmers own at least some hand-operated tools (hoes, shovels, etc.). Very few of the participating farmers own sprayers or dusters, which means that pesticide recommendations requiring their use would be difficult to follow. Plows, planters, cultivators, and other ox-drawn equipment were not owned by most of the participating farmers and they must gain access to equipment as well as draft animals for field work. The scarcity of harrows indicates that seed beds may not be well prepared and the lack of planters and cultivators indicates that most planting and cultivating must be done by hand, which could produce uneven stands (uneven seed depth and spacing), lower quality weeding and moisture penetration, and lower yields.

Table III-C-4. Percent of households owning and managing livestock, 1980-81 farm records program.

	Siloe	Nyakosoba	Molumong	Average
Cattle (all types)				
Own	60.0	46.4	86.2	63.3
Manage	51.7	71.4	82.8	64.1
Sheep				
Own	35.0	21.4	65.5	39.3
Manage	28.3	25.0	62.1	35.9
Goats				
Own	35.0	17.9	62.1	37.6
Manage	33.3	25.0	51.7	35.9
Horses				
Own	26.7	39.3	65.5	39.3
Manage	26.7	29.3	58.6	37.6
Donkeys/Mules				
Own	18.3	17.9	27.6	20.5
Manage	20.0	21.4	31.0	23.1
Pigs				
Own	43.3	25.0	13.8	31.6
Manage	43.3	28.6	13.8	32.5
Chickens				
Own	71.1	60.7	86.2	72.7
Manage	73.3	64.3	86.2	74.4

Source: Plath, 1982, RD-B-1.

A tentative classification of the participating farmers was developed based on the ownership of ox-drawn plows, planters, and cultivators. Between 69% (Molumong) and 93% (Nyakosoba) of the participating farmers own none of these items or owned only a plow. The majority of these poorest farmers managed less than four cattle, and they averaged less land per household and adult labor per household than did their better-off neighbors.

One conclusion is that the participating farmers are not a homogeneous group in terms of the resources that they own and control (land, labor, livestock, and equipment).

The households were arbitrarily divided into three groups based on their ownership of the basic ox-drawn implements, plow, planters, and cultivators. "Poor" households were defined as those households that do not own any of the three implements. "Middle" households owned a plow only, and "rich" households had a plow and a planter and/or a cultivator.

Table III-C-5. Joint ownership of ox-drawn equipment and management of livestock, 1980-81 farm records program.

	Siloe	Nyakosoba	Molumong	Average
Percentage of households with:				
No plow, planter or cultivator	45.0	60.7	17.2	41.9
Plow only	35.0	32.1	51.7	38.5
Plow plus planter and/ or cultivator	18.3	7.1	31.0	18.8
Average number of cattle managed by households with:				
No plow, planter or cultivator	0.6	1.7	1.2	1.0
Plow only	3.8	4.9	11.1	5.9
Plow plus planter and/ or cultivator	2.0	8.5	27.1	9.8
Of those who own the following pieces of equipment, the percentage who manage at least 4 cattle:				
No plow	3.7	11.8	20.0	8.2
Plow only	47.6	66.7	73.3	60.0
Plow plus planter and/ or cultivator	81.8	100.0	100.0	90.9

Source: Plath, 1982, RD-B-1.

The majority of farmers in each of the three areas were classified as either "poor" or "middle" in all three areas (Table III-C-9). This re-emphasized that many farmers do not own the basic ox-drawn equipment (plows, planters, and cultivators) needed for field crop production practices. In terms of land, those households that owned the basic ox-drawn implements were also better endowed. This was the case for both the number of fields and the number of hectares.

Wealthier households controlled more cattle than the poorer households (with the exception of Siloe where the "rich" average 2.0 cattle per household and the "middle" average 3.8). The percentage of households managing at least four cattle increases rapidly from "poor" to "middle" to "rich", with all "rich" households in Nyakosoba and Molumong managing at least four cattle.

Plath proposed that the groups tentatively classified as "poor" and "middle" be the groups to which the majority of the efforts of the Farming Systems Research Project be targeted. The primary reason for his proposal was that these groups represented the majority of farmers

Table III-C-6. Incidence of equipment and tool ownership, 1980-81 farm records program.

	Siloe	Nyakosoba	Molumong	Average
Hand operated				
Hoes	96.7	92.9	93.1	94.9
Sickles	78.3	60.7	93.1	77.8
Spades/shovels	71.7	67.9	75.9	71.8
Rakes	23.3	10.7	41.4	24.8
Forks	8.3	3.6	24.1	11.1
Wheel barrows	25.0	0.0	34.5	21.4
Sprayers/dusters	6.7	0.0	6.9	5.1
Animal operated				
Yokes	55.0	42.9	82.8	59.0
Plows	53.3	39.3	82.8	57.3
Planters	16.7	3.6	10.3	12.0
Cultivators	13.3	3.6	34.5	16.2
Harrows	16.7	10.7	44.8	22.2
Carts	5.0	0.0	10.3	5.1
Sledges	25.0	3.6	44.8	23.9
Tractor operated	None	None	None	None

Source: Plath, 1982, RD-B-1.

Table III-C-7. Land allocation by area, 1980-81 farm records program.

	Siloe	Nyakosoba	Molumong	Average
Number of farmer participants	60	28	29	
Total hectares allocated	195.9	40.6	73.7	103.4
Total fields allocated	145	58	74	92.3
Average				
Fields per household	2.4	2.1	2.6	2.4
Hectares per household	3.3	1.5	2.5	2.7
Hectares per household member	0.6	0.4	0.4	0.5
Percentages of total land				
Land in crops[1]	54.0	93.9	95.4	69.1
"Subsistence" crops	42.9	78.9	77.5	55.2
"Cash" crops	2.3	10.3	5.5	4.2
Intercropping	9.5	3.7	12.4	9.6
Land fallow or abandoned	46.0	6.0	4.6	30.9
Average per field				
Hectares	1.4	0.7	1.0	1.1
Parcels	NA	5.1	6.9	NA
Household members	2.3	1.8	2.6	2.2
Adult laborers	0.9	0.8	0.8	0.8
Average per hectare				
Household members	1.7	2.6	2.6	2.0
Adult laborers	0.7	1.1	0.9	0.8
Plows	0.2	0.3	0.4	0.3
Planters	0.1	0.0[2]	0.0[2]	0.1
Cultivators	0.1	0.0[2]	0.2	0.1
Harrows	0.1	0.1	0.2	0.1
Cattle managed	0.9	2.2	5.7	2.2
Sheep and goats managed	4.0	4.7	29.5	10.1
Horses, donkeys and mules managed	0.2	0.7	0.5	0.7
Cultivated hectares per				
Household member	3.1	2.7	2.7	2.9
Adult laborer	1.2	1.2	0.9	1.1
Adult male labor equivalent	0.9	0.9	1.0	0.9

1. "Subsistence" crops are maize, wheat and sorghum. "Cash" crops are peas and beans. Intercropping refers to the practice of having more than one crop on a piece of land--the plants of the different crops are intermixed.
2. Figures are greater than 0.0, but less than 0.5.

NA Data are not available.

Source: Plath, 1982, RD-B-1.

in the three areas. It would have been difficult to directly help the "poorest of the poor" without direct transfers of resources to them, something the Project was not designed to do. The proposed alternative would benefit them indirectly by improving the possibility for exploiting their primary resource, family labor. The "rich" were expected to benefit indirectly since much of what would aid the "poor" and "middle" groups would also aid them.

Table III-C-8. Land needed for self-sufficiency in basic crops (hectares per person), 1980-81 farm records program.

	Average yields[1] (kg/ha Planted)			A.A.R.[2] (kg per person per yr)	Land needed to satisfy ARR (ha/person)[3]		
Crop	Siloe	Nyakosoba	Molumong		Siloe	Nyakosoba	Molumong
Maize	1053	863	953	67	0.085	0.104	0.095
Sorghum	1057	904	767	22	0.028	0.032	0.038
Wheat	1083	1298	1377	37	0.046	0.038	0.036
Beans	485	552	414	6	0.016	0.014	0.019
Peas	755	963	595	5	0.009	0.007	0.011
Total	-	-	-	-	0.184	0.195	0.199

1. Average yields for 1973/74-1977/78 (except beans in Molumong are for 1974/75-1977/78). Yields from Mohale's Hoek District used for Siloe, Maseru District for Nyakosoba, and Mokhotlong District for Molumong. (Bureau of Statistics, 1979).

2. A.A.R. means Average Annual Requirement for Lesotho based on FAO nutrient requirements (Anderson, p. 13a). The total requirement for beans and peas is 11 kg, the distribution in the table is arbitrary.

3. Land Needed (LN) was calculated using the following equation:

LN = (AAR)/(Average Yield * 0.75)

This calculated for every crop in each area.

Average yield is reduced by 25% to account for the amount saved for seed and lost in storage.

Source: Plath, 1982, RD-B-1.S

Table III-C-9. Characteristics of poor, middle and rich households[1], 1980-81 farm records program.

Household type by characteristic	Siloe[2]	Nyakosoba	Molumong
Percent of total households			
Poor	45.0	60.7	17.2
Middle	35.0	32.1	51.7
Rich	18.3	7.1	31.0
Average no. of fields per household			
Poor	2.0	1.9	2.0
Middle	2.4	2.3	2.1
Rich	3.3	2.5	3.7
Average no. of hecatares per household			
Poor	2.7	1.1	1.8
Middle	3.2	2.0	2.1
Rich	4.7	1.6	3.8
Average no. of adult laborers/household			
Poor	1.6	1.4	1.2
Middle	2.5	2.0	1.9
Rich	2.7	2.5	3.2
Average no. of absentee adult male laborers per household			
Poor	0.6	0.6	0.6
Middle	0.9	0.7	0.7
Rich	0.4	0.7	0.4
Average no. of cattle managed by household			
Poor	0.6	1.7	1.2
Middle	3.8	4.9	11.1
Rich	2.0	8.5	27.1
Percent of household managing at least four cattle			
Poor	3.7	11.8	20.0
Middle	47.6	66.7	73.3
Rich	81.8	100.0	100.0

1. The households were typed on the basis of ownership of ox-drawn plows, planters and cultivators as follows:
"Poor" households own none of the above equipment;
"Middle" households own a plow only, and
"Rich" households own a plow and a planter and/or cultivator.

2. One household in Siloe owned a cultivator, but not a plow or a planter and was excluded from this analysis.

Source: Plath, 1982, RD-B-1.

Land area did not appear to be a severe constraint to most of the farmers in the targeted groups. If they planted all of their land and got average yields for their areas, most of the farmers would be self-sufficient in the basic crops (maize, sorghum, wheat, beans, and peas) (Table III-C-10).

The resources that appeared to be most constraining to agricultural output were the scarcities of draft animals and ox-drawn implements. Scarce resources adversely affect the ability of farmers to accomplish the required field crop tasks properly and in a timely manner.

Most of the farmer participants were involved in mixed farming (crops and livestock). The actual cropping pattern of individuals was determined by the needs and interests of the farmers and by the environment (climate, soil types, elevation, etc.). Cattle, sheep, and goats were the principal types of livestock managed. It is argued that the efforts of the Project should primarily concentrate on these principal crops and livestock types, and recognize that they form part of a mixed and interacting system.

Plath suggested that research be directed toward identifying constraints to production; seeking methods of improving production within those constraints by removing or bypassing them; investigating the economics of improved technologies, especially those that required additional inputs such as fertilizers and improved seed; and developing methods to make better use of available resources.

d. A Second Look at the Tentative Classification of Households in the Prototype Areas, (Plath, 1982, RD-R-2, a sequel to RD-B-1).

After the 1980-81 growing season Plath was interested in exploring two questions:

- What were the differences, if any, in the way the groups classified by resources allocated their land, and did availability of resources affect productivity?

- Was the classification system useful for differentiating farmers in the three prototype areas, and as a basis for making recommendations?

The data indicated the "rich" tended to plant more of their land to grain, particularly maize, than did the "poor" farmers. The "poor" allocated more of their land to legumes, beans, and peas, and left more of the land fallow (Table III-C-11A). There were no consistent yield differences among the three classifications of farmers. Differences were due to the "rich" having more land and not leaving as much of it fallow as did the "poor" farmers (Table III-C-11B).

Plath points out the difficulty in answering the question of land use and productivity in precise terms: "This leads to the conclusion that simply making more of the traditional non-land resources available to farmers (draft power and equipment, for example) might not necessarily increase yields. Total production would probably increase as the poorer farmers would be able to cultivate more of their land, but the farmers who have these resources already have not demonstrated that they consistently get higher yields. Yields might be increased as a result of greater resource availability if the richer farmers concentrated more on their own crops rather than on working the fields of their neighbors, if that is why their yields were generally disappointing.

"If the "rich" were encouraged to concentrate their efforts on their own fields to increase their yields without simultaneously making more resources available to their poorer neighbors, the result could be disasterous for the poorer farmers. The "poor" rely heavily on the "rich" in order to get at least some of their land plowed and planted."

Table III-C-10. Degree of self-sufficiency[1] in crop production by group, 1980/81 (percentage of minimum nutrient requirements produced).

Crop type and group	Siloe	Nyakosoba	Molumong
		(%)	
Grain			
(Maize, sorghum, and spring wheat)			
Poor	76	80	97
Middle	48	126	109
Rich	84	204	178
Legumes			
(Beans and peas)			
Poor	2	28	291
Middle	22	66	195
Rich	21	273	12

1. Degree of self-sufficiency is defined as the percentage of the basic crops needed to meet the minimum nutrient requirements that each group produced. The minimum nutrient requirements were taken from Anderson (p.13a) and were 124 kg of grains and 11 kg of legumes per household member per year. Also, these calculations assumed that the total production is available for consumption. No consideration was made for seed for the next growing season or for storage losses.

Source: Adapted from Plath, 1982, RD-B-1.

In discussing the second question raised about the usefulness of the classification system used to describe prototype farmers according to available resources, Plath writes: "Is the classification of "poor", "middle", and "rich" farmers useful? Although the names given to each of the three groups may not be wholly appropriate, it is believed that the basic classification is useful. It has been shown that the farmers in the three prototype areas were not homogeneous in resources, in their use of land, in their production of crops, or in

Table III-C-11A. Land allocation by group: Summer 1980-81. (Percentage of land planted to each crop, and percentage of farmers in each group who will grow the crop).

	Siloe		Nyakosoba		Molumong	
	Land (%)	Farmers (%)	Land (%)	Farmers (%)	Land (%)	Farmers (%)
Maize						
Poor	11.2	48.2	45.7	88.2	5.9	40.0
Middle	10.4	61.9	59.7	88.9	34.5	86.7
Rich	30.2	72.7	68.7	100.0	57.8	88.9
Sorghum						
Poor	26.7	70.4	15.4	35.3	3.6	40.0
Middle	23.5	61.9	5.5	33.3	6.7	26.7
Rich	24.9	72.7	7.7	50.0	4.0	44.4
Spring wheat						
Poor	0.0	0.0	11.0	17.7	46.4	100.0
Middle	0.0	0.0	19.2	55.6	35.9	66.7
Rich	0.0	0.0	12.1	50.0	21.8	77.8
Total grains						
Poor	37.8	77.8	72.2	94.1	56.0	100.0
Middle	33.9	81.0	84.3	100.0	77.0	93.3
Rich	55.2	90.9	88.5	100.0	83.5	100.0
Beans						
Poor	0.5	7.4	5.2	23.5	0.9	40.0
Middle	2.1	9.5	4.4	33.3	6.9	53.3
Rich	1.8	9.1	11.2	50.0	1.1	22.2
Peas						
Poor	0.0	0.0	5.9	35.3	12.5	60.0
Middle	0.3	4.8	5.1	55.6	6.9	53.3
Rich	0.0	0.0	0.0	0.0	1.1	22.2
Total legumes						
Poor	0.5	7.4	11.1	52.9	13.4	80.0
Middle	2.4	14.3	9.5	66.7	7.2	66.7
Rich	1.8	9.1	11.2	50.0	1.9	55.6

their ability to produce enough to meet their own needs. However, it was not shown that the "rich" are necessarily better farmers, at least in terms of yield. In seeking ways to raise yields and improve productivity, it is believed very strongly that the differences among farmers must be borne in mind. The "rich" are in a better position to acquire non-traditional inputs and to make better use of them, whether they do or not. And since they own more of the traditional resources, the "rich" are in a better postition to improve their management of these resources. But it must be remembered that they are a minority

Table III-C-11B. Crop yield by group 1980-81 (kg per planted hectare).

	Siloe yields		Nyakosoba yields		Molumong yields	
	Mean	Range	Mean	Range	Mean	Range
Maize						
Poor	115	0-724	423	0-2818	121	0-530
Middle	83	0-255	426	0-904	447	0-1136
Rich	110	0-193	588	548-682	746	447-2423
Total	105	0-724	441	0-2818	620	0-2423
Sorghum						
Poor	363	56-1350	593	0-1250	125	-
Middle	287	24-868	238	0-391	391	122-1125
Rich	372	62-773	0	-	411	56-1112
Total	339	24-1350	459	0-1250	394	56-1125
Wheat (spring)						
Poor	-	-	404	154-750	650	258-1313
Middle	-	-	356	125-441	525	172-1060
Rich	-	-	1846	-	541	265-1256
Total	-	-	464	125-1846	541	172-1313
Beans						
Poor	86	71-107	433	0-781	375	-
Middle	31	0-73	194	100-643	656	-
Rich	38	0-67	667	-	115	-
Total	40	0-107	383	0-781	257	115-856
Peas (spring)						
Poor	-	-	42	0-390	845	826-887
Middle	-	-	57	0-102	801	460-1127
Rich	-	-	-	-	41	0-150
Total	-	-	48	0-390	724	0-1127

and "solutions" for them may be irrelevant to the other groups. Furthermore, a potential secondary effect of helping the "rich" become better farmers is that the "poor" could become even less self-sufficient in food production and more dependent upon off-farm income sources.

"What is obvious from the data presented here is that resources by themselves, and under the current farming systems, do not make better farmers and necessarily lead to higher productivity. The priority seems to be to make the existing resources more productive through better management. The judicious introduction of new resources (improved seeds and fertilizers, for example), in conjunction with better management of the traditional resources, could increase productivity and production. Care must be exercised in all cases to help assure that the "poor" are not excluded from the process. Otherwise they could be made worse off, both relatively and absolutely."

e. 1980-81 Production in the Three Prototype Areas. (Plath, 1982, RD-B-3.

This report describes and discusses the production of maize, sorghum, wheat, beans, and peas in three areas of Lesotho during the 1980-81 summer growing season. The production practices associated with each crop are detailed in addition to the yields.

The data presented show that the farmers in Siloe, Nyakosoba, and Molumong invested a fair amount of time and effort to grow maize, sorghum, wheat, beans, and peas during the 1980-81 summer growing season, yet the yields were generally quite low. An examination of the rainfall and temperatures did not reveal any major reasons for the low yields, although some stress caused by weather may have been hidden in the data. For example, the monthly rainfall may have been adequate, but if it all fell in a 1-week period followed by a 3-4 week dry period the effect may reduce crop yields. Yet when the farmers were asked what would have increased their crop production, few mentioned weather specifically. Similarly, a comparison of the farmers with the highest yields with the other producers of each crop did not reveal any clear reasons for the yield differences.

Clearly more work must be done to determine the reasons for the low yields. It may be that while a single factor (method of planting or time of planting, for example) may not influence yields greatly, several factors together may make a significant difference. Plath suggested farm records data for the 1980-81 growing season, and subsequent growing seasons, should be computerized to allow more sophisticated and detailed analyses.

One reason why it was not possible to identify specific "keys" to improve crop production may be in the way in which the data were collected. Further, farm records programs can be successful only if the farmers accurately report the data and if the field workers do a good job recording it. The data collection forms and procedures were modified for the 1981-82 growing season in an effort to improve the

quality of the data collected. Also, with a year's experience the farmers and the field workers had greater familiarity with the procedures and, it is hoped, the farmers had developed more trust in the field workers.

An important step to improve agriculture is learning the critical factors. This report is a first step in documenting current crop production practices in Lesotho. It describes what was done during one growing season, but not why. The severe resource constraints faced by many of these farmers (Plath, 1981, RD-B-1) influence what they are able to do. For example, limited oxen for draft power, plows, and planters mean that all plowing and planting cannot be done in a short period and that not all crops can be planted with a planter. But there might be methods by which the scarce resources could be better utilized. However, even with better resource utilization it may be best to have a relatively long planting season due to rainfall variability. If, for example, a farmer has three parcels of maize planned, it may be best to plant them at different times. Torential rains or a drought period could result in complete crop failure if all the maize were planted at once, but with staggered planting dates the probability of having at least some production may be increased.

The report concludes that there is a clear need for more research into crop production in Lesotho. As a necessary step in the process, existing production methods need to be understood before they can be improved. The authors expressed a hope that this report would a first step in achieving that understanding.

f. 1980-81 Crop Enterprise Budgets: Traditional Production Practices (Plath, 1982, RD-R-3)

This report discusses and analyzes some crop enterprise budgets that had been calculated for five crops for the 1980-81 summer growing season. The five crops were maize, sorghum, spring wheat, beans, and spring peas. The production coefficients and practices used to prepare the budgets were derived from data collected from 117 farmers who participated in the farm records program during the 1980-81 summer growing season.

Analysis of the budgets indicated that peas had the greatest potential for higher returns, followed by sorghum and maize. Sorghum showed the least variability in response to yield and price changes, followed by beans, spring wheat, maize, and peas. Sorghum did not show any negative returns, which supports the conclusion reached in another study that sorghum will likely produce some yield.

This analysis from one year's data was not sufficiently complete to answer all the questions that arose. The many different production practices, as well as the effects of weather, soil, temperature, and other enviornmental factors made identifying reasons for different yields impossible. The study does provide some information about the

economics of producing the five major crops grown in Lesotho, and also provides some direction toward future research efforts. Part of the data from this study is provided in Tables III-C-12 and III-C-13.

3. The 1982-86 Period

Dr. David W. Holland was the farm management economist on the project during 1982-86.

The work of the Farm Management Section may be defined as investigating the economics of Lesotho's agriculture. Particular attention is given to production rather than marketing. The activities and research program during 1982-86 are described as summaries of publications in these categories:

- the economic and historical development of agriculture in Lesotho,
- the costs and returns of agricultural enterprises in Lesotho,
- the financial results of the "combination farmers" program,
- the results of tests of new agricultural technology, and
- a summary of the major findings of farm management research in Lesotho

a. The Baseline Survey

Because of the historical development of Lesotho's agriculture it was important to better understand the social and economic differentiation which characterizes rural Lesotho as a guide to agricultural research and extension education. The most important work was the Baseline Survey conducted in 1981 under the direction of the Rural Sociology Section in the Research Division. A 15% random sample of rural households in the three research prototype areas, Siloe, Molumong, and Nyakosoba was surveyed. The questionnaire was designed to contain information on social, economic, and biological aspects of agriculture in Lesotho. It expanded on and complimented the survey conducted by Plath of farmers in the records keeping program.

The Baseline Survey has been the source of data for three Research Division publications from the Farm Management Section. Aspects of economic differentiation and agricultural commercialization in Lesotho's agriculture were examined in RD-B-14. A review of agricultural problems as identified by respondents to the survey was provided in RD-B-20. Finally, the classification of Lesotho's rural population into target groups based on economic and social criteria was discussed in a paper jointly authored with the Rural Sociology Section (RD-B-46).

b. Differentiation and Commercialization of Lesotho's Agriculture (RD-B-14)

Data from the Baseline Survey indicate that although Lesotho's agriculture is indeed little commercialized, ownership of livestock and field tillage equipment is highly differentiated. The top 10% of cattle-owning families control 50% of the cattle. Concentration is higher for goat and sheep ownership where the top 10% of sheep and goat owners control about 80% of the respective herds.

Table III-C-12. Comparison of revenues and returns for traditional technologies: 1980-81.

	Revenues and returns (Maloti)				
	Maize	Sorghum	Spring wheat	Beans	Peas
Revenues					
Per hectare					
Low yield	36.63	93.50	51.80	75.00	41.00
Medium yield	146.52	130.90	129.00	125.00	164.00
High yield	283.05	224.40	207.20	200.00	369.00
Per man-day of labor					
Low yield	0.48	1.40	0.68	0.83	1.24
Medium yield	1.93	1.95	1.70	1.39	4.97
High yield	3.72	3.35	2.73	2.22	11.18
Returns[1]					
Per hectare					
Low yield	-56.76	11.16	-51.75	-35.31	-34.29
Medium yield	47.63	46.69	22.06	12.19	82.56
High yield	177.34	135.52	95.88	83.44	277.31
Per man-day					
Low yield	-0.75	0.17	-0.68	-0.39	-0.04
Medium yield	0.63	0.70	0.29	0.14	2.50
High yield	2.33	2.02	1.26	0.93	8.40
Per ox-day					
Low yield	-1.42	0.33	-1.44	-0.82	-0.78
Medium yield	1.19	1.37	0.61	0.28	1.88
High yield	4.43	3.99	2.66	1.94	6.30

1. Returns are defined as total revenue minus total cost.

Table III-C-13. Sensitivity of returns per hectare to yield and output price changes, by crop, using traditional technologies: 1980-81

	Grain yield[1]		
	Low	Medium	High
Maize prices (Maloti/kg)[2]	(110 kg)	(440 Kg)	(850 Kg)
0.133	-56.76	47.63	177.34
0.200	-49.39	77.11	234.29
0.266	-42.13	106.15	290.39
Average return: M87.18			
Sorghum prices (Maloti/kg)[2]	(250 kg)	(350 kg)	(600 kg)
0.124	11.16	46.69	135.52
0.186	26.66	68.39	172.72
0.248	42.16	90.09	209.92
Average return: M89.26			
Spring wheat prices (Maloti/kg)[2]	(220 kg)	(500 kg)	(800 kg)
0.209	-51.75	22.06	95.88
0.324	-30.75	74.56	179.88
0.418	-9.95	126.56	263.08
Average return: M74.40			
Bean prices (Maloti/kg)[2]	(150 kg)	(250 kg)	(400 kg)
0.45	-35.31	12.19	83.44
0.68	-0.81	69.69	175.44
0.90	32.19	124.69	263.44
Average return: M80.55			
Pea prices (Maloti/kg)[2]	(100 kg)	(400 kg)	(900 kg)
0.31	-34.29	82.56	277.31
0.47	-18.29	146.56	421.31
0.62	-3.29	206.56	556.31
Average return: M181.64			

1. Grain yields were used to calculate the budgets.

2. The lowest grain prices were used to calculate the budgets. The medium and high prices are, respectively, 1.5 times and 2 times the prices used in the budgets.

As mentioned previously there is very little production for exchange (sale) and very little use of purchased inputs. Typically less than 10% of the families used commercial seed or fertilizer. Chemical weed control was not reported by any surveyed family. Ownership of ox-drawn planters, cultivators, and harrows typically ranged between 5 and 15% of the families in the survey. Only 21% of the families owned at least two oxen.

Turning to the importance of off-farm work for wages, quite a different picture emerges. Thirty percent of the heads of the sampled families were working in South Africa. Another 6% were living elsewhere in Lesotho. When asked to identify their primary source of cash income, 84% of the families listed off-farm work.

The basic picture is one of a traditional agriculture penetrated by extensive wage work in other sectors, mainly in South Africa. Most families who do have land do not have a basic complement of tillage equipment, draft power for their equipment, or knowledge of the possible benefits of improved varieties of seed and fertilizer. Many families, due to the importance of wage work in South Africa, do not have sufficient male labor to complete the necessary field tasks on time. More significantly, there is not much interest in agriculture on the part of many such families because of the higher earnings thought to be available from wage work in South Africa. Clearly, an important implication of this work is the need to recognize that the rural population in Lesotho, contrary to appearances, is highly stratified in interest in agriculture and production capability. Planners should consider this distinction and not treat Lesotho farmers as a homogeneous group when designing research and extension strategies. The identification and use of target groups of farmers based on economic as well as ecological criteria seems especially appropriate in Lesotho. Preliminary work in this area (Tshabalala and Holland, RD-B-46) will be summarized next.

c. Target Groups (RD-B-46)

Target groups or recommendation domains were identified for the rural population of Lesotho on the basis of their ownership of agricultural resources. Five different groups were identified according to access to land, labor, and agricultural capital. Land was measured by ownership of fields, labor was measured by residency of the household head in Lesotho, and agricultural capital was measured by investment in oxen and investment in ox-drawn tillage equipment (Table III-C-14).

Information from the FSR baseline survey was the basis for classifying rural families into recommendation domains. The group having control of significant amounts of all agricultural resources was only 6% of rural families (Table III-C-14). The significant thing about this group is that they alone may be considered to have the resource capability to respond to any yield-increasing agricultural technology improvements for field crops. In a real sense, a research program focused simply on improving agricultural yields will find its main audience is this group for the full package of technology improvement.

The 6% of the families control 12% of the land. The production response of an agricultural technology improvement program that is implicitly for this group, or an unfocused one that only they can participate in, will not be large because they don't control sufficiently large amounts of land. In contrast, in the U.S., an untargeted agricultural crop technology improvement program will typically be used by the more progressive producers and have a large production response (increase in agricultural supply). While the new technology in the U.S. may be appropriate to only a small percentage of the farmers, this group controls a large proportion of the land and

Table III-C-14. Number and percent distribution of the rural population according to recommendation domains: Molumong, Nyakosoba, and Siloe (N=441).

Ownership of resource	Molumong		Nyakosoba		Siloe		All	
	R[1]	M[1]	R	M	R	M	R	M
Land, oxen, equipment	11 9.6[2]	2 1.7[2]	5 3.3[2]	4 2.6[2]	4 2.3[2]	1 0.6[2]	20 4.5[3]	7 1.6[3]
Land, oxen, no equipment	16 13.9	6 5.2	32 20.9	14 9.2	22 12.7	6 3.5	70 15.9	26 5.9
Land, no oxen, no equipment	21 18.3	6 5.2	28 18.3	8 5.2	48 27.7	21 12.6	97 22.0	35 7.9
No land, oxen, no equipment	6 5.2	7 6.1	6 3.9	8 5.8	3 1.7	5 2.9	15 3.5	20 4.5
No land, no oxen, no equipment	20 17.4	17 14.8	28 18.3	16 10.4	20 11.7	40 23.1	68 15.4	73 16.6
Unclassified	1 0.9	2 1.7	1 0.6	3 2.0	3 1.7	0 0.0	5 1.1	5 1.1
Total	75 65.2	40 34.8	100 65.4	53 34.6	100 57.6	73 42.2	275 62.4	166 37.6
Sample	115		153		173		441	

1. R = Resident; M = Migrant

2. Percent of the prototype sample

3. Percent of the total sample (N=441)

Source: Baseline Survey, Farming Systems Project, 1981.

other productive capital. When this group improves their productivity the impact on total output is large because a large proportion of farmland is affected. Therein lies an important difference for Lesotho. With its relatively unconcentrated pattern of land ownership, Lesotho cannot expect such a production response to an untargeted research program. This is why recommendation domains are important in planning agricultural research and extension in Lesotho.

At the other end of the resource scale, 31.9% of the families owned no significant amounts of land, equipment, or oxen (Table III-C-14). Their capacity and probably their interest in any sort of a research program dealing with field crops is likely to be very limited. With limited research resources it is perhaps best to omit them from a field crops program at this time and instead involve them in horticulture or small livestock improvement, if they are interested.

The recommendation domains provide a basis to stratify the rural population of Lesotho into groups having similiar argicultural resources and constraints. By concentrating particular research on relaxing those constraints it should be possible to improve the cost effectiveness of both argicultural research and extension efforts in Lesotho. At this point more work needs to be done on designing and tailoring research programs to specific recommendation domains. The first step in this process would be the selection of farmers in specific recommendation domains for further interview, testing, and refinement of a research program to relax their main constraints. For this work the farm records program would be very useful. It could identify farmers who fall into the various recommendation domains for further interview and testing.

d. Agricultural Problems Perceived by Lesotho Farmers (RD-B-20)

Bulletin RD-B-20 presented data from the Baseline Survey where the respondents were asked to identify the main agricultural problems they faced. It was clear from the data (Tables III-C-15 and III-C-16) that many farmers lack tillage equipment as well as oxen (the lack of oxen is expecially acute in Siloe, in the southern lowlands). As a result they must depend on sharecropping or hiring these inputs. Since a relatively high proportion of families are in similar positions, a relative shortage of tillage power is encountered. This finding agrees with what Plath reported (RD-B-1), and as he suggested, the result is either hastily or, poorly prepared fields, or fields in which field operations are carried out beyond optimal planting time. In Siloe, this bottleneck is a major factor in the failure to even plant a crop. An important mechanism to relieve this bottleneck is increased use of fall and early winter plowing. The oxen are in better shape, and at this time field work helps control insects and weeds. The fields should be plowed while they still have some moisture, not while they are too dry, or large clods will be formed in the heavier soils that will make spring tillage even more difficult.

The problem of seedling emergence was mentioned consistently by farmers in both Nyakosoba and Siloe, especially Siloe. Both

commercial and local varieties were affected. Some of the problem can be traced to poor seedbed preparation. However, as has become clear since the survey, much of the problem results from special soil properties found in each area. In Nyakosoba the dark red soils have a very low pH and crops such a maize and sorghum have emergence problems. In Siloe the problem seems to be soil texture. The sandy loam tends to dry out rapidly and after a hard rain, cakes and forms a hard crust which seedlings have trouble penetrating. Given the practical difficulties of correcting low pH, the optimal strategy to improve emergence in Nyakosoba is probably choosing acid-tolerant crops to grow on the higher acid soils. In Siloe, the best strategy is to plant when soil moisture is optimal, and then be prepared to replant in the event of unfavorable weather.

The main reasons for "failure to harvest" were drought in Siloe and early frost in the mountains and foothills. Given the importance that many families place on minimizing any possible loss from agriculture, this means that considerable research emphasis should be on crops and varieties of crops that are especially drought tolerant for the southern lowlands, and crops that are cold tolerant and quick maturing for the mountains. For Siloe the clear implication is that grain sorghum must be the crop given top research priority. For the foothills and mountains the choice of a priority crop is not so clear. A rotation of summer wheat-peas-potatoes-animal forage is probably best for the colder subregions. Since many farmers, even in the mountains, will insist on growing maize, attention should be given to a quick-maturing variety that will out perform the local variety, American White Flint. The Highland White Flint developed at the Thaba Tseka project appears to be an excellent candidate and will be discussed in the section dealing with the on-farm trials.

Table III-C-15. Ownership of usable ox-drawn or tractor tillage implements.

Type of implement	Percent ownership in prototype area		
	Siloe	Nyakosoba	Molumong
Plow	38	59	51
Cultivator	5	15	17
Planter	9	9	4
Harrow	13	13	17
Cart	7	3	1
Sledge	23	24	27
Yoke	42	60	57
Sample size	173	153	115

Source: Baseline Survey - Farming Systems Project

e. Labor Migration and Agricultural Development

An important aspect of farm management research has been to compare the income of Basotho migrants to South Africa with the income they say would be required from agriculture in Lesotho to consider remaining on the farm. From this data the capital and land resources required to generate the necessary income may be determined. The research on these issues is summarized in the M.S. thesis by Carvalho (1984) and in RD-B-34.

Table III-C-16. Ownership of oxen.

	Prototype area		
	Siloe	Nyakosoba	Molumong
No oxen	83	62	56
One ox	8	12	10
Two oxen	6	11	6
Three oxen	2	5	8
Four oxen	1	5	8
Sample size	173	153	115
Mean ownership per household	.3	.9	1.4
Percent households owning any oxen	17	38	44
Percent households owning at least one pair (i.e., cultivating/cart team)	10	26	31
Percent households owning at least two pairs (i.e., a plow team)	2	10	17

Source: Baseline Survey - Farming Systems Project

RD-B-34 combines some of the findings from several previous studies into a more complete examination of the labor migration/agricultural development issue in Lesotho. It therefore represents one of the more important bulletins written by the Farm Management Section. First, an analytical framework to view the issue of agricultural technology improvement in the case of migrant workers/farmers is developed. Second, estimates of the yearly income from agriculture needed to prevent migration are provided. Finally, resource requirements needed to produce the required income from alternative agricultural enterprises are determined and some policy implications are discussed.

In order for new agricultural technology to be attractive to a land owner working for wages in South Africa, it must be more productive than the old technology, and it must allow the generation of net farm income greater than the opportunity cost of the individual's labor. In other words, not only must the technology itself be profitable, but the whole farm operation must be able to generate more economic surplus than working for wages in South Africa. Thus, there is an effective "screen" on improving productivity through improved technology for such households compared to more traditional peasant farmers.

This analysis requires that information be gathered on the range of income required to stay in Lesotho and the magnititude of economic surplus associated with agriculture in Lesotho. Only in this way is it then possible to speak of a "viable" farm unit managed by former migrants, and the magnititude of resources required for such a unit.

Thirty-four experienced Basotho migrants, employed in the mines of South Africa, were interviewed in the Nyakosoba prototype while they were home for the Easter holiday in 1983 (Carvalho, 1984, ch. 3). These migrants indicated that their average annual income from wage employment in the mines was M2,524 (Table III-C-17). The miners also indicated that they would, on average, require an annual income earned in Lesotho of M1,536 in order not to migrate. Thus the migrants indicate that on average they would be willing to forego M988 (the difference between the two means) or nearly 40% of their gross wage in order to stay in Lesotho.

Possible income from agriculture was presented under three alternatives:

- traditional crops grown under traditional technology,
- traditional crops grown under improved technology, and
- orchard production.

The various practices associated with each alternative are fully described in the bulletin along with price and yield assumptions. The use of a full package of improved technology increased the average net return from traditional field crops by a factor of 4-5. With as

Table III-C-17. Approximate yearly migrant incomes and yearly incomes needed to stop migrating, Nyakosoba area, 1983.

Annual migrant incomes earned in the RSA			Annual income needed to not migrate		
Income (Maluti)	Relative freq.(%)	Cumulative freq.(%)	Income (Maluti)	Relative freq.(%)	Cumulative freq.(%)
540	2.9	2.9	600	3.2	3.2
720	2.9	5.9	630	3.2	6.5
900	2.9	8.8	720	3.2	9.7
1080	2.9	11.8	900	16.1	25.8
1440	8.9	20.6	1000	12.9	38.7
1500	2.9	23.5	1080	3.2	41.9
1620	2.9	26.5	1200	3.2	45.2
1800	8.8	35.3	1350	6.5	51.6
1980	2.9	38.2	1440	3.2	54.8
2070	2.9	41.2	1620	6.5	61.3
2160	2.9	44.1	1800	22.6	83.9
2340	2.9	47.1	2700	6.5	90.3
2520	2.9	50.0	2900	3.2	93.5
2700	11.8	61.8	3000	3.2	96.8
2799	2.9	64.7	3600	3.2	100.0
2970	2.9	67.6			
3330	2.9	70.6			
3600	14.7	85.3			
3690	2.9	88.2			
4050	2.9	91.2			
4131	2.9	94.1			
4410	2.9	97.1			
4500	2.9	100.0			
2524 (mean)			1536 (mean)		
3600 (mode)			1800 (mode)		
2550 (median)			1357 (medium)		

Source: Carvalho, 1984, pp. 97 and 100.

Three of the miners surveyed did not respond to the question regarding the income they would need to stop migrating. The frequencies have been adjusted to reflect this.

(Note: If the reported 1984 average mine wage of M4250, as cited in the 1985 Lessotho Agricultural Situation Report, accurately represents the present situation, the impact of migrant work on Lesotho agriculture is even greater than when this study was conducted).

little as 2 ha of good soil in the Nyakosoba area, a rotation of maize, beans, sorghum, and potatoes was estimated to bring an average net return to family and farmer labor of M1,756 under the assumption of "replacement" prices. In other words, the return to labor approaches the figure that many of the miners said they would require to remain in Lesotho (Table III-C-18). A fully mature orchard of 0.5 ha was found to generate net returns on the order of M2,200, well above that amount most miners said they would require to become full-time farmers.

The finding that relatively high levels of economic surplus can be generated from simple rotations of traditional field crops with improved technology is in some contrast to arguments that have contended that future agricultural development in Lesotho should focus on intensive horticultural and livestock activities because they alone are capable of generating the necessary economic surplus. While not discounting the importance of these enterprises (especially orchards as appropriate for returning miners) it is also important to understand that field crops can be very profitable under good management.

While expected economic surplus under improved technology is high, the variability of net returns is also high. It is likely that production risk for field crops in Lesotho is an important deterrent to investment in improved technology. The analysis of weather data currently being conducted by the Farm Management Section will be a useful first step in designing management strategies to minimize risk from weather, and possibly even an insurance program that will reduce the production risk for Lesotho farmers.

The importance of production risk in combination with the rational lack of interest that most migrant farmers will exhibit for improved agricultural technology has broad implications for agricultural research strategies. If scarce agricultural resources are to be used to relax the resource constraints of migrant families, those improvements that increase the labor productivity of male labor are likely to be found most interesting by migrant farmer households. Orchards are an ideal agricultural enterprise for this group because they can be developed while continuing wage work (Carvalho, 1984).

4. Enterprise Budgets

Considerable work in the farm management section has been done in assemblying information on the costs and returns associated with various agricultural activities. Each enterprise budget provides a detailed accounting of the resources necessary to carry out each activity, expected resource cost, as well as expected yield, output price ranges, and net returns. Since very little of this work has been done in Lesotho it was important that the necessary economic benchmarks be established. Such benchmarks are critical for farmers, bankers and other credit managers, government agricultural planners, and policy advisors.

Table III-C-18. Costs and returns for traditional field crops with traditional and improved technology (replacement price).

	Traditional technology			
Crop	Total returns[1] (Maloti/ha)	Production cost[2] (Maloti/ha)	Net return to family labor[3] (Maloti/ha)	Hourly returns (Maloti/ hour)
Maize	132	60	72	.24
Sorghum	135	54	81	.23
Spring wheat	162	74	88	.32
Beans	232	81	151	.41
Peas	115	80	35	.19

	Improved technology			
Crop	Total returns[4] (Maloti/ha)	Production cost[5] (Maloti/ha)	Net return to family labor (Maloti/ha)	Hourly returns (Maloti/ hour)
Maize	750	223	527	1.73
Sorghum	660	158	502	1.38
Spring wheat	720	216	504	1.52
Beans	700	188	512	1.42
Peas	N.D.[6]	157	N.D.	N.D.
Potatoes	4200	800	3400	

1. Based on average yields in the crop years 1981-82 and 1982-83, Nyakosoba. (Source: Farm Records Program, Farming Systems Research Project, Ministry of Agriculture, Maseru, Lesotho).
2. Holland and Ts'iu, 1983, p. 10.
3. Net returns to operator's own and family labor, land, and management. For the traditional crops, all labor used was assumed to be unpaid operator and family labor.
4. Based on the lower range of average yields obtained by selected Nyakosoba farmers in crop years 1982-83 and 1983-84. The following estimates were used:

Crop	kg/ha	Crop	kg/ha
Maize	2,500	Pinto beans	700
Sorghum	2,200	Peas	--
Spring wheat	1,800	Potatoes	14,000

(Source: Holland and Ts'iu 1983, pp. 11-14 and Majoro and Holland, 1985)
5. Original cost estimate adjusted to reflect the cost of cutworm bait and stalkborer pesticide where appropriate (Holland and Ts'iu, 1983, p. 10).
6. Insufficient data.

a. Field Crops

Research Division report RD-R-33 contains enterprise budgets for the major field crops in Lesotho. Two sets of budgets were developed. In one group, traditional technology was assumed, in the second group, improved technology was represented. In both groups ox-drawn technology was assumed throughout.

The labor use portion of the budgets indicates that peas tend to require the least labor, while sorghum requires the most. Wheat requires much labor for harvesting given the common practice of cutting the crop with a hand sickle, and then threshing by hand. The measurement of labor is especially difficult in Lesotho because of variations in the working day from task to task and from person to person. The most recent estimate of labor requirements for field crops may be found in the bulletin describing results of the Farm Records Program for the 1982-83 crop year (Table III-C-19, from Majoro and Holland, 1986, RD-B-41).

Charging all resources except land their opportunity costs results in a production cost range of M130-147/ha under traditional technology. Typically the cost of the farmer's own labor makes up more than one-half of this cost. With improved technology, estimated production costs typically nearly double. Most of the increased cost associated with improved technology is for commercial fertilizer.

In one section of the report an analysis of crop yields necessary for profitable production, as well as historical data on actual crop yields in one prototype area (Nyakosoba) are presented (Holland and Ts'iu, 1983, RD-R-33, p.12). The calulation of break-even yields for traditional production practices shows them to be above average yields from the Nyakosoba prototype area (Table III-C-18). Farmers who produce less than the break-even yield are not receiving the opportunity return on their labor assumed in the budgets, M1.00 per working day. Break-even yields under improved technology have easily been produced by farmers in the combination farmer program.

b. Orchards

Enterprise budgets for orchards of pear, peach, apple, and apricot as well the semi-perennial crop of asparagus are presented in RD-R-29. Orchards may be very important to the future development of Lesotho's agriculture. Peaches, although a very small planting, are presently an important crop in Lesotho. With proper irrigation, the climate and topography of large areas in Lesotho are ideally suited for growing fruit. Furthermore, orchard development represents an ideal agricultural enterprise in a transition away from mining. With a small scale orchard such as represented in these budgets, the miner, by carefully timing his leave from work, could develop the orchard while contining to work in the mines. As the orchard matures and comes into production mine retirement would provide the necessary labor with the expectation of a relatively quick pay-off. Carvalho (1984) provides a more complete analysis of orchard development and its possible role in transition from migrant labor to agriculture.

Table III-C-19. Labor use (person days) by crop, 1982-83 cropping season.

Crop and activity	Prototype area			
	Siloe	Nyakosoba	Molumong	Average
Maize				
Land preparation	26	10	7	14
Planting	11	5	7	8
Plow/planting	26	23	11	20
Weeding	42	42	10	31
Harvesting	32	25	24	27
Total[1]	111	90	48	80
Sorghum				
Land preparation	24	0	8	16
Planting	10	0	18	14
Plow/planting	24	30	15	23
Weeding	24	74	8	35
Harvesting	23	68	20	37
Total	81	172	54	102
Wheat				
Land preparation	-	-	-	-
Planting	-	-	-	-
Plow/planting	22	19	22	22
Weeding	-	-	-	-
Harvesting	43	77	53	58
Total	65	96	75	80
Beans				
Land preparation	21	36	8	22
Planting	21	18	3	14
Plow/planting	20	0	0	20
Weeding	17	45	0	31
Harvesting	43	18	7	23
Total	102	117	18	90
Peas				
Land preparation	15	-	-	-
Planting	-	-	-	-
Plow/planting	35	22	13	-
Weeding	65	-	-	-
Harvesting	53	37	49	-
Total	153	59	62	-

1. The totals include land preparation and planting, except in the case of wheat, where only plow/planting as a single operation was used.

Source: Farm Records Program - Research Division, Ministry of Agriculture.

Another component of orchard development is marketing. Most families in Lesotho have cash as a result of wage work and are accustomed to buying fruit through commercial channels. If unblemished fruit is produced locally, carefully transported, and competitively priced, marketing should not be a problem.

The orchard budgets are set up for 120 trees on 0.5 ha. A supplemental irrigation system for hand watering is incorporated into the budgets. The orchard is assumed to be fenced to deter theft. Other necessary assumptions are detailed in Carvalho and Holland (1983, RD-R-29).

The capital cost of establishing a 0.5 ha orchard is about M3,000. For most fruit varieties, production can be expected to begin in the third or fourth year. Depreciation and maintenance reserves will require about M200 per year. Variable costs in years of full production will consume about M500 per year.

When the orchard comes into full production, revenues in the neighborhood of M3,000 per year can be expected depending upon price and fruit variety. Peaches and apples were estimated to be the most profitable. Net return to farmer and family labor was M2,300-2,500 per year. This compares favorably with typical wages earned in South Africa for the same period as the budgets.

The work on enterprise budgets for orchards just described was updated and extended in 1986 (Snir and Holland, RD-R-60). In this report improved estimates of fruit yields, output prices, and input requirements are provided. Additional budgets are also presented for a fully commercial orchard of 3 ha.

The budgets for the fully commercial orchard show that while the costs of establishing such an orchard are high, the net returns are expected to be high as well. For a capital cost of about M28,000 the orchard may be established (Snir and Holland, RD-R-60, p. 12). Gross-returns of M45,000 per year may be expected when the trees are mature with depreciation and variable costs consuming about M12,000 per year. The resulting return to labor of M33,000 must be used to pay principal and interest on borrowed capital, hired labor, as well as to reward the farmer's own labor.

c. Irrigated Vegetables

There are three publications from the farm management section that are relevant to irrigation development in Lesotho. The most extensive set of crop budgets prepared thus far is for irrigated vegetable crops. These budgets were a central input to a linear programming analysis of optimal enterprise combinations for irrigated farming in Lesotho by Borris (Borris, 1985). The budgets have also been published by Research Division so that they may reach a wider audience in Lesotho (Borris et al., 1985, RD-B-36). Lastly, a Research Division bulletin has been written that traces the history and development of irrigation projects in Lesotho and attempts to suggest improvements for further development (Borris and Holland, 1986, RD-B-45).

Interest in irrigated crop production in Lesotho predates independence. Dams built mainly for soil conservation, but having an irrigation potential, can be found scattered throughout the Kingdom. Approximately 10 irrigation pilot projects were introduced into Lesotho between 1964 and 1975. All of the early pilot projects were located along the western perimeter of the country in the lowlands. For the most part, these schemes were originally designed, or consequently used as production units for researching and developing viable irrigation systems in Lesotho.

Lesotho has also seen the initiation of large, area-based, integrated agricultural development projects under donor sponsorship which contained significant irrigation elements. Three major ones were the Senqu, the Hololo Valley, and the Phuthiatsana Projects.

Borris and Holland (1986, RD-B-45) provide a map showing the location of all past and present irrigation projects, along with a chart showing the present status of each project. Historical reviews are presented for two representative pilot projects and all three area-based projects. The objective of the historical analysis is to provide recommendations for organization and operation of irrigation projects that will allow the mistakes of the past to be avoided in future efforts. Major findings for this study are summarized on pp. 64-76, and should be read by anyone involved in future irrigation development efforts in Lesotho.

Irrigated crop budgets were prepared for the seven crops currently imported in the greatest quantities (Borris et al., 1985, RD-B-36): onions, tomatoes, potatoes, cabbage, beetroot, carrots, and pumpkins. Production is assumed to take place on a 1 ha irrigated farm, not situated near a river, in lowland Lesotho. The budgets are constructed for 0.1 ha. The capital assets reflected in the budgets are those of the whole 1 ha scaled to 0.1 ha for cost estimates.

For some of the crops more than one budget was developed. This was done for two major reasons. First, there are varietal differences which affect both the cost of production, the expected yield, and time of marketing. These differences are most apparent for cabbages and tomatoes. Second, there are seasonal price differences. Onions, for example, can be grown for the low-priced summer season and if transplanted can be produced to meet the generally higher prices attainable in the winter months. Thus, two budgets were prepared for onions.

Under the assumptions made in these budgets the vegetable crops showing a positive return to labor and management are direct-sown onions, transplanted onions, early-variety tomatoes, and late-variety tomatoes. Crops showing negative returns are pumpkin, all cabbage crops, potatoes, carrots, and beetroot. The crop showing the most negative return is pumpkin and the crop showing the least negative returns is beetroot.

Several points have become clear with the development of these budgets. First, the importance of petrol costs is clearly underlined. Petrol expenditures far exceed seed, fertilizer, and pesticide expenditures for every crop except potatoes, where the cost of seed potatoes is large. Assuming the formulas are correct, it is the petrol expenditure necessary to run the irrigation pump that looms relatively large, and this is a cost that is not easily avoided without jeopardizing the entire crop. The recent (1985) 50% increase in the petrol price appears to have diminished the profitability of irrigated farming considerably. If the future is characterized by further petrol price increases, the short-run impact will be even greater pressure on net returns.

Second, for a whole-farm production situation as represented by these budgets, irrigated vegetable production is not likely to be a panacea to Lesotho's agricultural development problems. While specific rotations have not been examined, it appears that once the financial needs of capital have been serviced, the returns to labor are virtually nonexistant. A major difficulty is that those crops that would allow double cropping seem to exhibit negative returns to labor.

It is possible that economies of size are available in the machinery and irrigation systems so that with a little increase in the capital endowment assumed for a 1 ha farm, a larger land area could be served, and thereby generate increased returns to labor per unit of land. It may also be possible to reduce the capital intensity by eliminating certain pieces of equipment (the truck, the rototiller, the size of the dam) and farm a somewhat smaller area with a smaller capital endowment per land area and thereby increase the returns to labor unit of land.

In any case, a 1 ha commercial operation as depicted in these budgets will have profitability problems. A semi-commercial operation of perhaps 0.25-0.5 ha may overcome some of the capital intensity problems that the more commercial operations seem to encounter. Certainly in terms of financial resources likely to be available to potential farmers, and in terms of potential marketing problems, the smaller operation has much to recommend it. It is left to others to selectively modify these budgets to explore the net returns associated with other farm size/capital intensity assumptions, and the possible net return levels associated with alternative whole farm plans.

It will be seen from the budgets that estimated returns are very sensitive to yields and prices received. Prices received were estimated as the Bloemfontein wholesale price averaged over three recent years for the month(s) when the crop was estimated to go to market. It is possible that growers in Lesotho will be able to get higher prices, but it is possible that with inexperience and poorly functioning markets they would receive lower prices.

Yields were conservatively estimated based on available publications and the collective judgement and the Lesotho experience

of the authors of this publication. Some growers with experience, good soil, and a favorable season, will be able to produce higher yields than those indicated in this bulletin. Their gross returns will increase accordingly. However, less-skilled operators will be unable to even match the yields indicated herein, particularly in an unfavorable season.

d. Results from Combination Farmers

As part of the research program coordinated under the Farm Management Section, two farmers in each of the three prototype areas were selected for special attention. The individuals were called "combination farmers" and were chosen because they had the necessary resources of land, oxen, and equipment, as well as the ability and interest to work with personnel from the Research Division. These practices that the combination farmers were generally asked to try were backed by good agricultural research evidence, and the farmers were expected to pay for the cost of the necessary inputs. The farmers had the option of rejecting or modifying any proposed practice if they didn't feel it was appropriate to their particular farming situation. In some cases the farmers also paricipated in trials where they were not expected to pay input costs.

Two research reports describing costs and returns associated with field crops grown by the combination farmers were written: RD-R-37 summarized the results of the 1982-83 season, and RD-R-49 summarized the results of the 1983-84 season. The results of a winter fodder trial will also be reviewed in this section as this trial was conducted with a combination farmer, and subsequently became the basis for part of the combination farmers program in the southern lowlands. It is from the results of the combination farmers program that an idea of how the full package of improved field crop technology under farmer conditions is best obtained.

The summer growing season of 1982-83 was the first for personnel of the Research Division to work with the combination farmers. Modifications to existing practices were mainly concentrated on field crops. Implemented practices were those basically described in the Research Division Cropping Guidelines. For most farmers, it involved increased use of commercial fertilizer, limited use of pesticides to control cutworm and the stalkborer in maize and sorghum, use of hybrid varieties of maize and sorghum, planting with a planter, and production of fodder sorghum in the Molumong area. Correct time of planting and early weeding were also stressed.

In valuing crop production, two separate prices were used. One price was the official government wholesale price. The other price was what was termed the replacement price. In grain-deficit areas in Lesotho, the prevailing grain price was far higher than official price. This higher price is thought to reflect the alternative of obtaining the grain through commercial channels, and the transportation and storage costs associated with such channels. The commonly accepted price for maize, for example, was M0.30/kg or

approximately 50% higher than the official government price. For the farmer in such areas it is the value of grain at replacement price rather than official price that provides the most accurate figure for computation of the return to the farmers labor.

Siloe--1982-83. Sorghum was the only summer crop to show a positive return to the farmers labor in the 1982-83 season (Holland and Tsiu, RD-R-37, p. 6). In terms of drought resistance, it is a low-risk crop and deserves special attention in the southern border lowlands. Another management strategy that deserves attention is the application of LAN fertilizer as a top dressing. Both of the combination farmers in Siloe were reluctant to apply LAN, arguing that the year looked so dry that no benefit from top dressing would occur. No LAN was applied and as it turned out the farmers were right. It is believed that the application of top dressing is best approached as a problem in conditional rainfall probabilities in Siloe, and probably the rest of Lesotho. In wet years the application of LAN will have high payoff and it should be heavily applied. In dry years just the opposite is the case. The question is, can the farmer tell the difference at the time? Our personal opinion is that the answer is yes, although sound scientific evidence is not yet available.

In Lesotho periods of good rains seem to be followed by periods of good rains. Large fronts move in, and often stay for three or four days. A heavy rain on one day is often a good predictor of good rains to come in the next few days. The alert farmer can use the first-day rain as an indicator to apply top dressing to the field for the next few days. Likewise, the weather reporting in South Africa is quite extensive. When there are general rains in South Africa it is usually a good indication that there will be several days of rain in Lesotho. Also, good rains in November seem to indicate a higher likehood of good rains in December and January. As previously mentioned, a study of weather probabilities (rainfall, frost, and hail) is currently underway in the Farm Management Section and is scheduled to be finished in May 1986. The results of this study will be summarized as they become available and should have important implications regarding a risk-minimizing, LAN fertilizer strategy. Should the evidence corroborate the previous statements, the role of top dressing needs to be re-emphasized as a practice that depends upon the rains.

Nyakosoba--1982-83. In 1982-83 the Nyakosoba prototype received better rains than either Siloe or Molumong. Wheat, maize, and beans all proved to provide relatively high returns to labor in Nyakosoba. Spring wheat is well suited to the higher altitude regions of the area with potential yields of 1,400 kg/ha (Holland and Tsiu, 1983, RD-R-37, p. 11). The major problem with wheat in the high altitude areas of Lesotho is wild oats, and the large labor requirement for harvesting and threshing. The problem of wild oats can be successfully addressed by growing wheat in rotation with peas (maize or sorghum can't be used because they will not survive the cool weather) that are planted in rows so that they may be cultivated and weeded. Much of the drudgerey with threshing wheat can be reduced with mechanical threshing, to be discussed in a later section.

The combination farmer who weeded her maize on time received an estimated yield of 1,615 kg/ha in spite of a poor stand. This indicated that with a better stand, yields four or five times the average for the area (400-600 kg/ha) could be expected and a decision was made to change to a stronger-germinating maize variety for the next year.

Molumong--1982-83. Wild oats were a serious weed problem in the higher altitude region of the Molumong prototype area. One wheat field was completely destroyed and a pea field substantially damaged. The importance of having a row crop in a wheat rotation to help control wild oats in the mountains became very clear. The crop that works best is peas because it can withstand the cool weather and can be planted in rows for cultivation.

Highland maize bred on the Thaba Tseka project was introduced and did fairly well (yield of approximately 1,000 kg/ha) in a dry year. Yields were reduced by the lack of moisture and the tendency of the highland varieties to lodge. In very windy sites highland varieties are not the best choice.

The production of forage sorghum in the lower altitude region of the protytype was a success despite overseeding. Once warm weather arrived, the crop grew very well. On a green weight basis the average yield was 24.4 t/ha (Holland and Tsiu, RD-R-37, p. 19). The farmer was enthusiastic about this crop and wanted to include it in the rotation for next year.

The 1983-84 growing season was the second season for the Research Division to work with the combination farmers. The report summarizing this experience is Majoro and Holland, 1985 (RD-R-49). In the second year, first-year practices were continued and additional attention was givin to growing an enterprize mix especially suited to each area. In the southern lowlands (Siloe), winter wheat and winter oats for fodder were stressed along with sorghum for the summer. In the foothills, double cropping with winter wheat, beans, and maize was tried. Production of higher- valued crops of potatoes, was tried in both the foothills and the mountains.

Siloe--1983-84. The growing season in Siloe was marred by drought that began in January and continued through February and March. Most maize fields were either destroyed or badly damaged. Since this was the second consecutive drought year, and after examination of long-term rainfall data from this area, the following conclusion is offered. It is very risky to grow maize in the border lowlands of Lesotho. The yields of grain sorghum for the combination farmers in Siloe averaged 897 kg/ha. It is believed that grain sorghum yields of over 1,000 kg/ha can be consistently obtained in Siloe with good agricultural practices (Majoro and Holland, 1984, RD-R-49).

Wheat was successfully grown by both of the combination farmers (average yield 756 kg/ha). The Russian aphid was a severe problem for winter wheat in August and September. Many Siloe farmers lost their

crop to this pest. Wheat that was planted by April and had established good growth by August was able to resist the infestation until the aphid's natural preditor, the lady bird beetle, was able to begin to control them. But wheat that was planted late, in June or July, was destroyed.

Winter crops for both food and animal fodder are an important component of an optimal farm plan for Siloe, but must be established in March and April to have a good chance of success (RD-R-49). This gives the crop a chance to establish before the cold weather in June and July, and also takes advantage of the fall rains before the dry winter season. For farmers growing a summer crop, this means that the crop cannot be allowed to completely dry in the field. Crops such as maize should be cut before complete drying and taken back to the house and stacked to finish drying. The leaves and stalks of such crops can be fed to livestock. The importance of quick maturing summer field crops, even for an area like Siloe with a long growing season, is clear. Pinto beans, which may be harvested in February are an excellent choice in a rotation involving a winter crop.

In a double-cropping rotation trial, pinto beans followed winter wheat on one-half the land with grain sorghum on the other half. This allowed two crops to be produced on one-half the land each year. After two years this rotation was modified to one involving a slightly less intensive pattern of land use. Two main problems were encountered. First, with the wheat harvested in December and the time required for the Christmas holidays, the beans could not be planted until January. The wheat often left so much stubble that a good seed bed was not established and the emergence of bean seedlings was poor. The other problem was that the sorghum was still maturing when the wheat should have been planted. The result was that the wheat was usually planted late and missed the fall rains (Alotsi and Holland, in review (b)). The rotation now being grown is winter wheat following pinto beans on one-third of the land. This gives plenty of time to establish the wheat as the pinto beans are harvested in February. Wheat is followed by oats to be used as winter fodder on one-third of the land, and the final third is a summer crop of grain sorghum. Under this rotation double cropping still occurs, but now there is more time for completion of the necessary field operations. For a more complete description of this rotation see Alotsi and Holland (in review (b)).

The lack of sufficient animal fodder is a perennial problem for farmers in Siloe. With so little feed available, animals taken out to graze return in the evening nearly as hungry as when they went out. The shepherd's time, which could be spent going to school, generates very little surplus. We believe that the best approach to livestock management for most families in Siloe is to not include sheep and goats in the operation. Most farmers have so few animals and they are so unproductive (Alotsi and Holland, in review (a)) that almost no loss of economic surplus would be involved if the sheep and goats were sold. As far as oxen are concerned, it is probably best to eliminate grazing and concentrate on growing field crops and fodder, making sure

that all the stover from those crops is returned to the house and stored for animal feed.

Excellent crops of winter fodder can be produced for animal feed. Oats is the best choice because it resists Russian aphids. As pointed out earlier, it is critical to establish winter crops no later than April. Growing winter fodder does not eliminate growing summer food crops. The fodder can be grazed out in plenty of time for planting a summer crop in the spring. For an investment of approximately M90/ha, fodder will return M400-M700/ha, depending on the current price of forage (Holland et al., RD-R-39, p. 4).

The general approach to livestock management just described (i.e., stall feeding oxen) has been tried with success by one of the combination farmers in Siloe. A big advantage with such an approach is that there is no need for a herdboy, and he can attend school.

The major problem with this approach to crop and livestock management is that it doesn't provide long term replenishment of soil organic matter since the straw is removed for livestock feed. The solution is probably to plant a winter crop for use as green manure. Oats can be grazed lightly and then plowed down for green manure; wheat would also be acceptable. Of course not all fields are suitable for winter cropping. Unauthorized grazing will be a problem where the field is so distant that the farmer is unable to protect it.

Nyakosoba--1983-84. The attempt at double-cropping with maize, winter wheat, and pinto beans had mixed results. Good yields of wheat and maize were obtained (Holland and Majoro, 1984, RD-R-49). It was proved that pinto beans could follow winter wheat and still produce a crop, however, there were fundamental problems. The wheat variety took too long to mature and left too much stubble in the field. A quicker maturing, short-stemmed variety is needed for double cropping. Also, the wheat crop must be well established early in the fall (March, April) before the really cold weather. With maize as the preceeding crop there isn't enough time between the maize harvesting and the proper planting time for wheat. Based on the trial experience, the tested double-cropping rotation cannot be recommended at this time for the foothills.

Potatoes as a nonirrigated field crop were grown by one of the combination farmers, and no major production problems were experienced. Yields of nearly 15 t/ha were produced resulting in a fairly high rate of economic surplus per unit of land (Holland and Majoro, 1984, RD-R-49, p. 25). No marketing problems were experienced. Potatoes appear to be an excellent cash crop in both the foothills and the mountains. They can survive moderate hail and frost, store well in the winter, and grow well even on relatively acid soils, but they do require a high expenditure for seed and fertilizer. Given the high cost of establishment and the problem of input transportation, large scale production of potatoes is not recommended, but on a small scale (approximately 0.2 ha) they are an excellent subsistence and cash crop. The BP1 variety has been more frost resistant than the Up-to-Date variety.

In general, most traditional field crops did well in the Nyakosoba area. Even grain sorghum did well when grown in the lower altitude region of the prototype area (Majoro and Holland, 1984, RD-R-49, p. 26). The two major problems with crop production in Nyakosoba are the relatively high altitude and cool temperatures, and the low pH of the dark red soil, which contribute to seedling emergence problems and an inconsistent reaction to commercial fertilizer. The best short-term solution to these two problems seems to be planting crops and varieties that are best adapted to those special situations. For example, a long-season grain sorghum would be a poor choice in the higher altitude regions (above 2,400 meters), but short-season varieties have done well in the lower altitude areas of the prototype area. Likewise, both maize and sorghum have emerged poorly on the high-acid, red soils, but potatoes and oats have done very well on such soils.

Molumong--1983-84. Potatoes were introduced into the rotations of Molumong combination farmers in 1983-84, as were sunflowers and grain sorghum on selected fields. The sunflowers and grain sorghum were intended for low rocky fields near the Senqu river, which had received little rainfall the year before.

The potatoes grew well, although they were attacked by blight and yields were below those recorded in Nyakosoba. Both the grain sorghum and sunflowers did fairly well. The grain sorghum was a quick-maturing, white variety and gives the farmer a number of options. The seeds may be consumed for human food or fed to chickens, while the stalks and leaves can be fed to livestock. In fields where drought is a problem, such as low rocky benches near rivers, grain sorghum is a good choice as a low-risk, multiple-purpose crop.

Both combination farmers were encouraged to grow some animal fodder on their crop land. Fodder sorghum was grown in the lower altitude region of the prototype area, while barley was produced in the upper region. The combination farmers were also encouraged to bring their crops in from the field in order to save all the stover. At home during the winter, the grain was then separated from the rest of the plant. There is often little animal feed on the range in the late winter so that supplemental feeding from stored feed can make a big difference in animal condition in early spring.

One practice that was not tried with the combination farmers was growing a crop of winter fodder. The results of previous winter trials in Molumong were discouraging. The combination of very little precipitation and the very cold nights killed or severely retarded all winter fodder trials. Also the winter fields must be planted before the summer crop is fully mature, so double cropping is not possible. The role of winter or annual fodder is important in the lowlands, but does not appear feasible for the mountains.

Finally, it should be noted that with the exception of one farmer in the Siloe prototype area, all of the combination farmers were able to generate returns to the farmer's labor and capital of over M1,000

per farm from field crops. It was shown that in the foothills and mountains, net returns per hectare for maize, sorghum, and wheat can approach M500-700 with good weather and good agricultural practices (Holland and Majoro, 1984, RD-R-49, p. 49). Potatoes averaged M2,270/ha. The importance of field crops in future agricultural research programs for Lesotho should not be forgotten.

5. Tests of New Agricultural Technology

a. Pinto Beans

Pinto beans were introduced into Lesotho, tested extensively in the Nyakosoba prototype area in a joint program of the Agronomy and Farm Management Sections during the 1982-83 growing season, and became the basis for a seed multiplication program in all three prototype areas in all subsequent years of the FSR program. The combination farmers were also introduced to pinto beans. In all cases the response was enthusiastic. Research report RD-D-28 describes the results of the first year of trials with the pinto bean, and explains in large part why it has proven to be such a popular crop.

For the pinto bean trial, one-half of the farmer's field was planted to pinto beans, and the other half to small white harricot beans. The two varieties received the same treatment. The pinto bean had the advantage of flowering and maturing significantly earlier than the small white harricot (SWH), while the SWH bean yielded more. It was the early maturity of the pinto over the SWH that was most interesting (118 days for the pinto compared to 144 days for the SWH) (Carvalho et al., 1983, RD-R-28, p. 4). With the constant danger of damage from hail and early frost in Lesotho, the probability of crop failure with pinto beans is reduced. Farmers were also happy with the eating quality of the pinto and its marketability.

The major problem with the pinto beans was to establish an optimal plant population. The SAFIM 6-hole maize plate that farmers often use to plant beans is not suitable to plant the smaller pinto bush bean; the plant population is too small. With the SWH bean the problem is not as severe because it is a larger, indeterminate-type bean and the holes in the maize plate sometimes allow two of the smaller SWH seeds to come out at the same time, thus increasing the plant population. For the pinto bean an 8- or 10-hole SAFIM plate was recommended to plant an optimal pinto bean population (Carvalho et al., 1983, RD-R-28, p.10)

The other major problem with pinto beans, as with any bean grown in Lesotho, is the CMR beetle. This has been a pervasive pest on most on-farm bean trials. However, very effective control of the CMR beetle can be obtained with carbaryl (Sevin) insecticide.

b. Mechanical Grain Threshing

In 1983 the Research Division obtained two small grain threshers manufactured in Egypt. The suitability of these machines was to be

evaluated under Lesotho conditions. An economic analysis of the threshers was done by the Farm Management Section and reported in RD-B-33. An unpublished report was also prepared by the Agronomy Section (VanEpps). The main emphasis of the Farm Management study was to determine possible grain saving using mechanical threshing, as well as calculating the costs and possible returns from the thresher operation.

It soon became clear that the machine had not been designed for Lesotho conditions. The thresher was supposed to be transported by animal draft power, and in the flat conditions of Egypt this would have been possible. But in the mountainous terrain of Lesotho, this was impossible. The machine was very heavy, not equipped with suitable tires, and had no braking system. The only way to move it was by truck. Substantial modification would be required to make the thresher suitable for Lesotho.

In trials where the efficiency of the machine was compared with hand threshing, the mechanized thresher saved an average of 21% more grain over traditional hand threshing (Table III-C-20). The machine saved about three-fourths of the labor required for hand threshing. For example, if a job required 100 units of labor time with hand threshing, it would require about 25 units of labor time with the machine.

The break-even charge for threshing sorghum was M1.50-2.00 per 70 kg bag, depending on the cost assumptions (Table III-C-21). This was apparently a price comparable to that charged by South Africans who formerly did custom threshing. It is interesting to note that the benefit from grain estimated to have been saved by use of the machine exceeded the entire fixed and variable cost of operating the machine for a typical day. The daily cost of operation was estimated to be approximately M31 per day while the value of grain saved was estimated to be M48 per day (Majoro and Holland, 1984, RD-B-33, p. 20). Based on the results, the increased use of small mechanical threshers could increase the economic surplus from field crop production in Lesotho as well as save some labor. The Egyptian threshers would require redesign for Lesotho conditions. After some alterations, operational break-even price would be viewed as reasonable by Lesotho farmers. The grain saving possible with mechanical threshing represents a considerable additional benefit from increased use of this technology. Manufacturing by Lesotho Steel, and testing by the Research Division of improved models, should be carried out.

c. The On-Farm Trials 1983-84

The on-farm trial program for the 1983-84 summer season was jointly planned and conducted by members of the Farm Management, Agronomy, and Extension Sections (Holland et al., 1985, RD-B-38). It represented a genuine interdisciplinary team effort. In this summary no attempt will be made to cover every trial, instead the more important results from a farm management perspective will be discussed.

Siloe. In Siloe most of the emphasis was on grain sorghum. Important trials were conducted on an improved opener (coulter) for the SAFIM planter, optimal plant populations for maize and sorghum, fertilization rates for maize and sorghum, and replanting skips and bare spots in maize fields by hand.

The improved coulter for the SAFIM planter was designed by members of the Research Division to place the fertilizer below the seed. An earlier improvement by the BASP program opened too wide a and did not place fertilizer to the side of the seed. The mean yield of those samples from the Phase II (Research Division) improvement were more that double the yields of those samples from the unimproved coulter (Holland et al., 1985, RD-B-38, p. 32). The difference was statistically significant.

Table III-C-20. Grain saving trials.

	First event		Second event	
	Traditional threshing (kg)	Mechanized threshing (kg)	Traditional threshing (kg)	Mechanized threshing (kg)
Total mass of unthreshed pile of sorghum	240	240	240	240
Total mass of grain after threshing	153	193	132	168
Differences	87	47	108	72
Yield difference between traditionally and mechanically threshed sorghum		40[1]		36[1]

1. Average percent loss = $\dfrac{\frac{40 + 36}{2}}{\frac{193 + 168}{2}} = \dfrac{38}{180.5} = 21\%$

Source: Trials in Siloe

Note: In this trial, the first event was a dry sample of white sorghum, while in the second event, a rather moist sample of red sorghum was used. In the second event the resulting chaff contained more grain in both methods. This fact does not alter our comparison capacity between the methods in that event, but does indeed reduce the comparability of the two events.

The plant population trials tested different row spacings. The better farmers seem to employ wider row spacings in Siloe. The row widths were the currently recommended 1 meter, 1.5 meters, and 2 meters. With the 12-hole seed plate used for grain sorghum this gave a seed population of 87,000, 58,000 and 48,000 seeds per hectare, repectively. The mean yield of the 2-meter spacing was nearly 500 kg/ha greater than the mean yield of the 1 meter spacing (Holland et al., 1985, RD-B-38, p. 23). The difference was significant at the 20% level. For maize, the difference was more dramatic in the sense that this was the only maize trial to survive to maturity in Siloe.

The mean yield of the 1.5 meter row spacing was the largest although not statistically different from the other two treatments (Holland et al., 1985, RD-B-38, p. 35).

While the statistical significance of differences in treatment effects was not high for the row spacing trials, they nevertheless have important implications. All indications are that maize is a risky crop to grow in the Siloe area, yet it continues to be grown on many fields because it is a preferred crop. Some of the risk can be taken out of maize production with an optimal plant population, in Siloe about 20,000 plants/ha, planted using a 5-hole maize plate in 1.5 meter rows. This approach has the added advantage of reducing the basal fertilizer rate to 3 bags/ha while maintaining the recommended rate per plant.

Replanting skips and empty spaces in maize by hand could not be accurately assessed for the Siloe area because two out of the three trials were destroyed by drought. However, the hand replanting mechanism worked well. The replanted sections filled in nicely and looked good until drought destroyed the crop. In a more normal year it is believed that many of the replanted maize plants would have produced ears and increased yields. Given the germination and emergence problems that farmers in Siloe seem to face, hand replanting of maize gaps appears to be a good idea.

Table III-C-21. Returns to owners' management and capital per day.

Price per bag	Machine output (no. bags)	Revenue per day	Costs per day	Returns to management and capital
M 2.50	20	M 50.00	M 31.07	M 18.93
2.00	20	40.00	31.07	8.93
1.50	20	30.00	31.07	-1.07
1.00	20	20.00	31.07	-11.07
0.40	20	8.00	31.07	-23.07

Source: Trials in Siloe

Molumong. Although Molumong is a very difficult area in which to do research because of its geographical isolation, it is still very important because it is representative of most of the land area of Lesotho.

In areas suitable for maize, the 1983-84 trials indicated that the variety Highland White Flint has great yield potential when properly fertilized and managed on mountain soils. The yield of Highland maize over all trials and treatments in which it was involved in Molumong was 2,706 kg/ha (Holland et al., 1985, RD-B-38, p. 74). This is the mean of eight different observations. The Highland is a quick-maturing variety and is open pollinated so that seed may be saved from one year to the next. The only disadvantage of Highland is its tendency to lodge.

Additional information on the performance of pinto beans in the mountains of Lesotho was produced from the seed trials. The pinto bean is not a good choice to be intercropped with maize or sorghum because the plants are small, but grown on its own it is a good producer. The mean yield from nine different fields in the Molumong prototype was 591 kg/ha (Holland et al., 1985, RD-B-38, p. 75). With an increased plant population and better control of the CMR beetle, it should be possible to expect yields of pinto beans of 1,000 kg/ha on good fields in the mountains. At a price of M1.00/kg this crop could bring gross returns of M1,000/ha.

Nyakosoba. Nyakosoba was similar to Molumong in many respects. The BASP version of the improved coulter did not increase maize yields in either Nyakosoba or Molumong. The Research Division version was not tested in Nyakosoba, but it was expected to work well on heavy damp soil because of its narrower design.

The hand replanter worked well in Nyakosoba and provided the only maize fields sampled with more than 20,000 plants/ha. The major problem with replanting is that it cannot be delayed or the new plants will not be able to compete with the original plants.

The problem of low plant populations was especially acute in Nyakosoba. The mean plant population for all maize trials in Nyakosoba was only 11,840 plants/ha. These were trials planted with viable seed at a rate of 47,362 seeds/ha. Regression analysis indicated that each 1,000-plant increase in plant population would have resulted in an additional yield of 140 kg/ha of maize. (Holland et al., 1985, RD-B-38, p. 77). In Nyakosoba there is a need to increase emergence percentage, and then preserve those plants that do emerge.

A major problem in Nyakosoba is the relatively high incidence of low pH soils. Such soils inhibit emergence percentage and react inconsistently to fertilizer. It is probably not within the means of most farmers to increase the pH with lime because of the quantities involved and the difficulties of transportation. A better strategy may be to increase the organic matter content with green manure crops in rotation with crops that prefer an acid soil. More agronomic and economic research is needed on this important problem.

d. Implications of the 1983-84 On-Farm Trials

A number of encouraging developments emerged from the trials. The Phase II coulter for the SAFIM planter generally worked very well in the Siloe trials. This coulter, with its narrow design, should overcome the problems that were experienced with the Phase I, and should be throughly tested on heavier soils. If it proves effective, arrangements should be made to have Lesotho Steel start making the Phase II improvement.

The row-spacing trials in Siloe were interesting because they were the only maize trials to survive in Siloe. In addition to increasing survival probabilities, wider rows allow the fertilizer rate per land area to be reduced while maintaining the fertilizer available to each plant at recommended rates. For maize, the desired plant population range in the southern lowlands is 18,000-20,000 plants/ha.

Although the winter plowing trial did not show a statistically significant difference in treatment effects, there can be no question that winter plowing must play an important role in proper soil management, soil moisture conservation, and optimal oxen use. An early winter plowing, followed by appropriate shallow cultivation in the spring will have numerous benefits, including moisture conservation, which is especially important in the southern lowlands.

The Siloe white sorghum variety Siloe Best preformed very well in the variety trial. Some of this seed should be saved and multiplied at the Research Division. PNR 8311 was the red variety used in the Siloe trials. It always emerged and yielded well. Farmers liked it because it was relatively easy to thresh and for this reason it was far more popular than NK300.

In Nyakosoba the grain sorghum variety called Nyakosoba White preformed very well for the combination farmers. This sorghum was obtained from a well known farmer (Makepe) in the lower end of the prototype area. Since this sorghum performs well in the foothills the seed should be preserved and multiplied by the Research Division.

6. Further Research Priorities

Future research plans cannot be clearly written at this time because of uncertainty regarding the status of the Farm Management Section in the upcoming LAPIS project. Since it appears that no PhD agricultural economist will be stationed at the Research Division in the LAPIS project, the resources of the Farm Management Section will be quite limited for some time to come. It will leave farm management with just two people, one of whom is expected to leave for degree training in August 1986. The remaining individual is trained to the B.S. degree level. The manpower situation in farm management will improve in one more year when another national trained with an M.S. in agricultural economics will rejoin the section.

Assuming the Farm Management Section is left with just one person the most that can be expected is that the existing system of enterprise budgets is maintained and kept up to date. Since all of the budgets are constructed on computer spreadsheets (VISICALC), updating the budgets with future prices and yields will be easier. The main budgets that should be maintained are those dealing with field crops, orchards, and irrigated vegetable crops.

If a Ph.D. agricultural economist can be maintained in the Research Division, then it will be possible to continue and extend ongoing work.

The following list represents priority items for further work in Farm Management (not necessarily listed in order of importance):

- livestock enterprise budgets;
- mixed livestock-crop, whole-farm, optimal combination analysis;
- further testing of grain saving and labor saving with small-scale mechanical threshing;
- completion and refinement of the Lesotho input-output model;
- refinement of target groups for Lesotho, and integration of this concept and knowledge into agricultural research and extension;
- development of management strategies for minimizing weather risk for field crops;
- development of a systematic research program to test small-scale mechanical tillers and carts.

Perhaps the greatest need at this time is to develop a set of enterprise budgets for small-scale livestock operations. Among the operations expected to attract the most interest would be poultry and dairy. The next logical step would be to look at crop-livestock enterprise combinations. Given the LAPIS focus there is going to be increasing interest in information on small stock operations, their feeding requirements, and the associated implications for crop production and/or grain and forage purchase. Linear programming would seem to be an ideal instrument to address these issues once the necessary livestock budgets are developed.

The work on current analysis of weather patterns in Lesotho should be extended and integrated into data collecting procedures of the Meteorology Division in the Ministry of Water, Energy and Mining. In particular the data that are being collected should be transcribed onto diskettes for the IBM computer, and merged with the past data files that have already been transferred to diskettes. In this way it will be very easy to extend the current analyses into the future and help cement a closer linkage between the Meteorology Division and the Research Division.

Additional testing of the grain saving possible with mechanical threshing should be done. The few trials that were conducted indicated considerable saving, but more are needed to verify these results. If the results are verified, mechanical grain saving can be expected to pay for itself in grain saving alone.

The Lesotho input-output model will be of great importance in planning the future agricultural development of Lesotho. Efforts should be made to integrate selected data collection efforts of the Bureau of Statistics into a periodic updating of this model. The Planning Division of the Ministry of Agriculture should also be aware of the model and its capabilities.

With increasing interest in irrigated horticultural production, the need for information on the possible role of mechanical tillers and carting systems is clear. For many farmers in the lowlands alternatives to oxen ownership must be considered. A research program on mechanical tillers and their place in Lesotho agriculture and its economy could make an important contribution to increasing agricultural productivity.

Finally, mention should be made of the work on target groups that has been carried on jointly between the Farm Management Section and the Rural Sociology Section. Because Lesotho's agriculture is highly penetrated by wage work in South Africa, it is important to have a clear idea of recommendation domains if research and extension funds are to be used efficiently. For this reason the current farm management and rural sociology work should be further refined and integrated into the research planning of the biological sections of the Research Division. Not only will this provide an improved focus for future research planning, but it will lay a foundation for true cooperation between social scientists and the biological scientists in the research division.

The executive summary of this section is on pages 52-56. The summary of accomplishments and recommendations is on page 95.

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D. Soils

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D. Soils

Soils, as a separate discipline, was not included as a major part of the original FSR Project. However, because of considerable interest in soils problems, consultants were brought to Lesotho to help evaluate these problems. A significant adjunct to the Project is the development of the soils laboratory during 1984-86 under the direction of a soil scientist.

This report is divided into three parts:

- Soil development, classification, and survey. (Soils of Lesotho).

  Project leaders were interested in the soil series and the soil properties where field trials were located. Some soils of the prototype areas were surveyed and characterized.

- Soil Erosion/Conservation

  This subject cannot be separated from important aspects of the Project: the range overgrazing problem, crop response on eroded soils, vegetation for erosion control, and general soil management.

- Soil Fertility Management

  An effort was made to relate fertilizer response and soil fertility problems to soil series. In addition, development of the Soils Lab was done with Project funds and has a relationship to the Project. There were a number of soil fertility trials by agronomy and horticulture personnel and some data were generated relating crop response to soils tests.

1. Soils of Lesotho

a. Factors of soil formation

Soil development depends on a combination of five factors: parent material, climate, living organisms, topography, and time. The relative importance of each factor varies from place to place, but in all cases, the factors tend to be strongly interdependent. For example, vegetation is a major factor affecting the properties of a soil, especially the surface layer. But the amount and type of vegetation depends greatly on climatic factors such as rainfall and temperature.

(1) Parent Material

Parent material is the unconsolidated material from which soils are formed. The parent material is usually, but not always, derived from consolidated rock material. In Lesotho, the rock formations are

basalt at elevations above approximately 1,750 meters, and sandstone or shale below this level. Thus, the mountain region soils and the foothill soils are underlaid with basalt, while the lowland soils are underlaid with sandstone or shale.

Soils formed in place from the underlying parent rock material are called residual soils. Other soils are formed on materials that have been transported, usually by wind or water, but sometimes by gravity or by glacial action. Both kinds of soil-forming materials are found in Lesotho.

(2) Climate

The effects of climate are both direct and indirect. There is a direct effect, for example, of moisture on the soil itself, e.g., the amount of downward leaching of plant nutrients into the soil profile. There is an indirect effect on the amount and nature of plant growth which, in time, has a substantial effect on soil properties, especially in the surface soil.

Rainfall, in Lesotho, although not high, has a pronounced effect on soil properties. The range of annual precipitation is from less than 500 mm in the Senqu River Valley to more than 900 mm in the mountains. Approximately 80% of the precipitation is in the summer--October through March.

Temperature is another important climatic factor. In Lesotho, summers are quite warm but not hot, with maximum temperatures averaging approximately 29°C. Winters are cool in the lowlands but not cold--occasionally getting below 0°C at night, resulting in light early morning frosts. Winters are colder in the foothills and much colder in the mountains than in the lowlands.

(3) Topography: Relief and Landform

The influence of topography is related primarily to steepness, length, and aspect (direction) of slope. Steepness tends to slow soil development because of more runoff and less infiltration, resulting in more erosion--both natural (geological) and man-made (accelerated)--and less effective moisture for plant growth and horizon development. Length of slope is a factor in that longer slopes accumulate runoff and result in more erosion than shorter slopes. Aspect is important primarily in its relationship with solar energy and temperature. North-facing slopes absorb more solar energy and tend to be warmer than south-facing slopes.

All this is important as it relates to the soils of Lesotho. The lowlands and the Senqu River Valley vary from 1,520-1,660 meters and occupy approximately 15% of the country. The gently undulating topography is spotted with steeply sloping remnants of the hilly uplands, and eroded, nearly level areas where sandstone and shale are exposed.

The foothills vary from 1,660-2,000 meters and occupy about 20% of the area. This rolling, hilly landform is interspersed with valleys and mountain spurs. Exposed bedrock occupies the higher areas.

The mountains in the central and eastern parts of Lesotho occupy about 65% of the country. The topogaphy is largely steep to very steep slopes at elevations up to about 3,400 meters. The area is marked by thin soils and exposed basalt on the slopes and thicker soils in the valleys.

Sharp differences in elevation in Lesotho are closely related to differences in internal drainage, external drainage (runoff), thickness of developed soil material, profile development and horizon differentiation, soil texture, and geologic and accelerated erosion.

(4) Living Organisms

Plant and animal life and their decomposition products have a great effect on soil development, mainly in their contribution to the accumulation of organic matter and the subsequent soil structure. Plant life contributes more than animal life. Living organisms can be placed into two general categories: micro and macroorganisms. Macroorganisms--especially higher plants--contribute greatly to the amount of organic material which becomes incorporated into the soil and eventually ends up as soil organic matter. Microorganisms are the bacteria, fungi, and algae in the soil and are active in the decomposition of fresh organic material and transformation into soil organic matter or humus.

While the amount of raw product (vegetation) is an important facter in the amount of organic matter, it is by no means the only factor. Other factors such as temperature and moisture are equally important since the rate of decay depends on these factors. In fact, in zones of very high temperatures and adequate moisture, there may be a great deal of raw product (vegetation) but resulting in only moderate levels of organic matter because of rapid decomposition. Soil organic matter tends, like water, to "seek its own level", that is, to come to equilibrium with its environment.

In addition to the accumulation of soil organic matter by decaying plants, the root systems of living plants affect soil structure, especially the surface soil, but also the subsoil. Small roots grow through the soil with great energy, causing groups of soil particles to collect into floccules. Eventually, if not broken down, the floccules become aggregates which are more or less stable in a desirable soil structure.

The amount of organic matter and the thickness and darkness of the surface horizon depend not only on the amount of plant material and the environmental factors, but also on the types of plants for the raw product. For example, grassland soils are generally much higher

in organic matter and have a darker and thicker surface layer than do forestland soils. This is reflected to a great extent in Lesotho's soils, most of which were formed under grassland.

(5) Time

Beginning with the raw product--parent material--the influence of the three environmental factors--climate, organisms, and topography--on development depends greatly on the length of time involved. Or conversely, the effects of time depend on the nature of the parent material, the intensity of the climate, the nature of the topography, and the type of vegetation. In the context of soil development, time is an indefinite term. A soil may become highly developed in a few decades or it may require several millennia depending on the other four factors.

Some of the soils of Lesotho are young and others are very old. Soils on steep soils, especially in the high mountains, are frequently young because of rapid geological erosion and constant exposure of new material. Likewise, some alluvial soils in river valleys are young because of periodic deposition of new materials. On the other hand, soils on middle or high terraces or on gently undulating or level areas may be much older. In fact, some soils exhibit characteristics of having developed long ago under an earlier hotter and wetter climate, dependent on the climatic factors of rainfall and temperature. Steepness of slope tends to limit water infiltration and increase runoff, resulting in less soil moisture for plant growth. Some parent materials are much more easily weathered than others so that less time is required for development. Parent material becomes a predominant factor in the final soil product in arid regions where climate and vegetation have little influence. In the Lesotho climate, organisms (vegetation) and topography are generally more important factors than parent material.

Without exception, some factors are interdependent, and a single factor never operates in isolation.

(6) Man

"Man has influenced soil formation, mostly adversely, by tillage, grazing, and burning practices ... He has mixed surface and subsoils, depleted organic matter, accelerated sheet and gully erosion, altered runoff and internal drainage, and upset the natural balance of flora and fauna" (Conservation Division, 1979).

Man has, mostly inadvertently, done all of the above in Lesotho. Of special significance are the effects of population pressure on the erosion problem. The sequence of events may be shown as follows:

Increased population ⟶ Increased Livestock numbers ⟶ Overgrazing ⟶ Severe erosion

Unfortunately, in Lesotho, the adverse effects of man's influence far outweigh the beneficial effects.

b. Soil Classification

Classification is a process in which units of a system are placed into categories which are distinguished by their properties. Soil classification is a science, not unlike the science of the classification of plants or animals. Each unit fits into its place in the classification system.

The soil classification system uses these categories:

- Order
- Suborder
- Great groups
- Subgroups
- Families
- Series

This report will be primarily concerned only with the order and the series categories. The other four categories, although essential elements of the system, require a complex discussion.

(1) The Orders

There are ten orders. Table III-D-1 shows the names and general features of the ten orders, while Table III-D-2 lists the five orders that occur in Lesotho along with the hectarage and extent in the country.

Table III-D-1. Soil orders and their general features.

Order	General features
Entisols[1]	Very young soils with little or no horizon development.
Inceptisols[1]	Young soils, slightly more developed than Entisols.
Mollisols[1]	Soils with dark, usually deep, surface horizon. High in organic matter.
Aridsols	Soils of arid regions.
Vertisols[1]	Clayey soils with high shrink/swell potential, cracks during dry periods.
Spodosols	Soils with spodic horizon.
Ultisols	Soils low in base saturation.
Alfisols[1]	Soils moderate to high in base saturation but highly developed.
Oxisols	Soils with oxic horizon.
Histosols	Organic soils.

1. One of the five orders identified in Lesotho.

Mollisols. Soils developed under grassland vegetation high in organic matter, are the most extensive in Lesotho. They generally have a dark, deep surface layer, but some shallow Mollisols are found on basaltic slopes of the mountains. Deeper soils are found in the mountain valleys and also in the foothills and lowlands. Three of the most extensive soils of this order are Popa (Fig. III-D-1), Fusi, and Khabos.

Alfisols. Highly developed, poorly drained soils that frequently have a thick clay layer below the surface layer. These soils are especially susceptable to gully erosion. In most cases the most suitable land use is grazing. Overgrazing and cultivation on these soils are hazardous since they tend to or accelerate serious erosion already occuring.

In Lesotho, some Alfisols are known as "Duplex Soils". Duplex soils have two distinct layers. The surface layer is coarse-textured and the subsoil is high in clay. The two layers are separated by a sharp boundary. "Duplex", a local term, is not a part of the classification system.

Entisols. Soils in a very early stage of development lacking distinct horizons. The most extensive Entisol is the Ntsi series, very shallow soils, less than 0.5 meters deep. Other Entisols are the Caledon and Morija series, which are suitable for a variety of crops and can be intensively cultivated under proper management.

Inceptisols. Young soils, but more developed than Entisols. They are moderately-well to somewhat-poorly drained soils in the foothill and lowland regions. The most extensive soil of this order is the Berea series which occur on sandstone plateaus.

Table III-D-2. The five soil orders in Lesotho and their approximate area and extent.

Order	Area ('000 ha)	% of Lesotho	No. of series
Mollisol	1,300	43	22
Alfisol	330	11	8
Entisol	120	4	5
Inceptisol	90	3	2
Vertisol	30	1	2

Adapted from Cauley (1985).

Vertisols. The root "vert" means to turn. Vertisols are soils high in clay that have high shrink/swell potential. When the soil dries, cracks appear--sometimes several centimeters wide--in the surface. Surface soil falls into the cracks and the surface layer tends to become inverted over time. The area is limited and is represented by two series, only one of which is an extensive arable soil, the Thabana series.

Duplex Soils. The term "Duplex" is not included as a part of the classification system, but special mention should be made of some soils of Lesotho that are unique, important and have special management problems. As indicated by the Conservation Division (1979, p. 20) "the Duplex or claypan soils are, as a group, the most extensive soils in the Western Lowlands and present the most perplexing problems in crop management and erosion control". They are positional in the areas of severe gully erosion which have resulted in "dongas". The upper layer consists of two or three bleached, highly-leached horizons, called the E horizon (formerly A_2 horizon). All truly Duplex soils are Alfisols but, in Lesotho, all Alfisols are not Duplex Soils, although there are some "Duplex-like" soils.

(2) The Series

A series includes soils of similar profile characteristics except texture of the surface soil. Series names are derived from a town or other geographical site.

There are approximately 40 series identified in Lesotho, 23 of which are Mollisols. This reflects that much of Lesotho is grassland and many of the soils were developed under grassland vegetation.

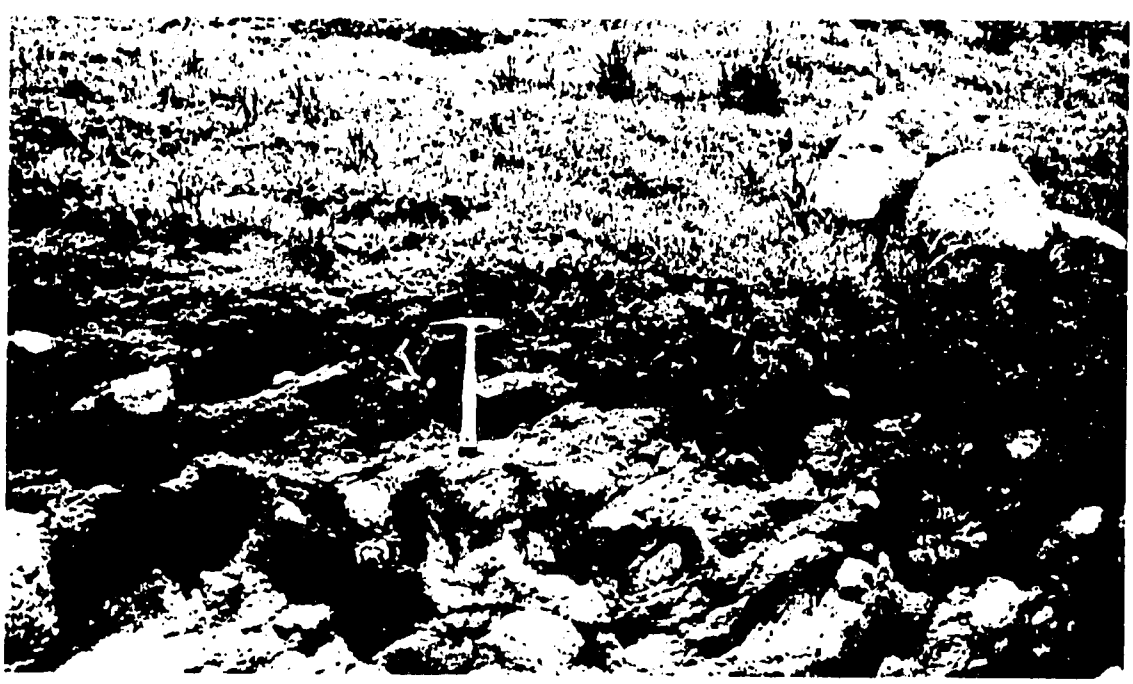

Figure III-D-1. Popa silt loam soil, a very extensive Mollisol, is typical of much of the mountain rangeland.

c. Soil Survey

The soil survey is an applied science in which a surveyor identifies various soils and determines how they fit into the classification system. A soil surveyor must be well trained in the disciplines of soil development and classification. He or she walks across the landscape, bores and digs, and maps the soils. The only units shown on the soil survey map are those of the soil series and the "mapping unit", a subunit of the series. Presumably, the soils within the area of a mapping unit are sufficiently similar to require the same management practices. The mapping unit can be conceptualized as a soil "individual". Mapping units within a series are separated largely on the basis of slope and surface texture.

d. Soils of the Prototype Areas

Field plots in each of the three prototype areas were surveyed rather intensively and soil samples were taken for analysis. The work was done by Mack (1986). "The soil resources of the Prototype areas differ in many ways. These differences are related to geologic, topographic, and climatic conditions inherent in each area. A total of 13 soils, fairly representative of much of Lesotho's agriculture, were examined." The series and some of their chemical and physical properties are shown for each of the areas in Tables III-D-3, III-D-4, and III-D-5.

Table III-D-3. Soil properties of the Siloe prototype area.

Series	Texture[1] Surf	Texture[1] sub	pH	AWC[2]	Tilth	Rooting zone (cm)	Organic matter	Drainage
Sephula	fsl	c	6.2	low	good	40-70	low	Mod. well-somewhat poorly
Maseru	fsl	c	5.7	low	good	30-60	low	Poorly
Berea	fsl	scl	5.3	low	good	100-150	low	Mod well-somewhat poorly
Matela	fsl	scl	5.3	low	good	150	low	Well
Caledon	fs	fsl	5.8	low	good	100-150	low	Well
Phechela	c	c	6.6	low	poor	100-150	high	Well-mod. well
Khabos	scl	scl	6.3	mod	fair	100-150	high	Well
Nitsi	fsl	fsl	5.3	low	good	50	low	Well

1. c = clay or clayey; s = sand or sandy; l = loam or loamy; si = silt or silty; f = fine
2. AWC = available water capacity

Source: Mack, 1986.

Table III-D-4. Soil properties of the Nyakosoba prototype area.

Series	Texture[1] Surf	Texture[1] sub	pH	AWC[2]	Tilth	Rooting zone (cm)	Organic matter	Drainage
Mats'aba	cl	c	4.6	mod	fair	50-100	high	Well
Machache	cl-c	c	5.2	mod-high	fair	100-150	high	Well
Thabana	si c	c	6.3	low	poor	100-150	high	Well-mod. well
Fusi	cl	c	6.1	mod-high	mod-poor	100-150	high	Well
Popa	l	cl	6.1	mod-low	fair	50-100	high	Well

1. c = clay or clayey; s = sand or sandy; l = loam or loamy; si = silt or silty; f = fine
2. AWC = available water capacity

Source: Mack, 1986.

Table III-D-5. Soil properties of the Molumong prototype area.

Series	Texture[1] Surf	Texture[1] sub	pH	AWC[2]	Tilth	Rooting zone (cm)	Organic matter	Drainage
Culmic Haplustol	l-cl	l-cl	7.2	high	fair	150	high	Well
Nkau	l-cl	cl-c	7.2	high	fair	150	high	Well
Typic Argiudoll	cl	c	6.7	high	fair-poor	100-150	high	Well
Udic Pullustert	c	c	7.2	low	poor	100-150	high	Well-mod-well
Thabana	si c	c	6.6	low	poor	100-150	high	Well-mod-well
Fusi	l-cl	l-cl	7.4	high	fair-poor	100-150	high	Well

1. c = clay or clayey; s = sand or sandy; l = loam or loamy; si = silt or silty; f = fine
2. AWC = available water capacity

Source: Mack, 1986.

e. Benchmark Soils of Lesotho

Identification of Benchmark soils serves a useful purpose. Benchmark soils are "key agricultural soils selected for detailed description characterization, classification and interpretation". (Cauley, 1985).

Cauley identified 11 soil series in Lesotho as Benchmark soils. Presumably, each of them is somewhat similar, in terms of use and management, to a number of other series. Thus, in total, the 11 Benchmark soils represent a reasonable cross section of the major agricultural soils of Lesotho.

Fusi Series--Mollisol. Deep, well-drained soils formed in the weathered products of basalt colluvium and residuum. Permeability is moderate in the upper part of the profile and slow in the lower part. They are characterized by mostly structureless, stratified, subsurface horizons that grade into either buried saprolite or a buried cambic horizon. Slopes range from 2-40%. The annual temperature is 12°C and the annual precipitation ranges 800-1,100 mm. Fusi soils are moderately extensive in the foothills and inextensive in the mountains. Most areas are cultivated and planted to maize, wheat, peas, or beans.

Khabos Series--Mollisol. Deep, well-drained, moderately permeable soils formed in alluvium dominantly of basalt origin. These soils are on low terraces and have slopes ranging from 0-7%. Annual temperature is 16°C and annual precipitation ranges from about 625-800 mm. These soils are inextensive and locally distributed, mostly on terraces along major streams in the western lowlands. The Khabos soils are extensively cultivated. Maize and sorghum are the principal row crops. Wheat is the principal small grain, and many areas are used for vegetable production.

Leribe Series--Alfisol. Very deep, well-drained, permeable soils formed in ancient basaltic alluvium and colluvium. They are characterized by buried, fine-textured, argillic horizons. These soils are on smooth, convex hilltops and sideslopes with remnants of ancient terraces and plantation surfaces. They have slopes ranging from 0-15%. Annual temperature is 16°C and annual precipitation ranges from 625-800 mm. Leribe soils are widely distributed throughout the western lowland and are extensive. They are extensively cropped with maize, sorghum, wheat, beans, and asparagus.

Machache Series--Alfisol. Deep, well-drained soils formed from basalt residuum. Permeability is moderate in the upper part of the solum and moderately slow in the lower part. They are characterized by a fine-textured surface layer overlaying a fine-textured argillic horizon. Slopes range from 2-15%. The annual temperature is 13°C and annual precipitation ranges 800-950 mm. Machache soils are widely distributed in the western foothills and are moderately extensive and are extensively cultivated. Maize, sorghum, beans, peas, and wheat are the most commonly grown crops.

Matela Series--Alfisol. Very deep, well-drained, permeable soils formed in alluvium and colluvium derived from basalt and sandstone over sandstone residuum. They are characterized by a moderately coarse-textured argillic horizon overlying a deeply buried fine-textured argillic horizon. These soils are on smooth, convex ridge tops and sideslopes, with remnants of ancient terraces and plantation surfaces. Slopes range from 0-15%. Annual soil temperature is 16°C and annual precipitation ranges 625-800 mm. Matela soils are widely distributed throughout the western lowlands but are inextensive. Almost all Matela soils are cultivated; maize, sorghum, wheat, beans are the most commonly grown crops.

Qalaheng Series--Alfisol. Deep, well-drained, permeable soils formed in weathered sandstone residuum. They are found on smooth convex upland sideslopes of 2-15%. Annual temperature is 16°C and annual precipitation ranges 625-800 mm. The Qalaheng soil is widely distributed and moderately extensive in the western lowlands. Most areas of Qalaheng are cultivated. Maize, sorghum, wheat, and beans are the main crops.

Rama Series--Alfisol. Well-drained, slowly permeable soils that are moderately deep to a root-restricting, concretionary layer. They formed in ancient basaltic alluvium. These soils are on ancient terraces or planation surfaces and have slopes ranging from 0-15%. They are characterized by well-developed concretionary layers which occur within a depth of 65-120 cm. Annual temperature is 16°C and annual precipitation ranges 625-800 mm. They are widely distributed throughout the western lowlands and are moderately extensive. The Rama soils are extensively cultivated. Maize, sorghum, wheat, and beans are the most commonly grown crops.

Sefikeng Series--Alfisol. Very deep, well-drained permeable soils formed in residuum from basalt. These soils are on uplands and have slopes ranging from 2-15%. Annual temperature is 13°C, and annual precipitation ranges 800-950 mm. The Sefikeng soils are extensively cultivated. Maize and wheat are the most common crops. They are widely distributed in the western foothills and are extensive.

Sephula Series--Alfisol. A typical Duplex soil moderately-well to somewhat-poorly drained that is moderately shallow to moderately deep to a fine-textured, impermeable, root-restricting layer. They are formed in shale residuum that has undergone strong eluviation in the upper solum (Fig. III-D-2). This gives the impression of a two-story soil with medium-textured material lying directly on clay. A characteristic abrupt textural change with an associated albic horizon occurs at the contact between the two types of material. These soils are at the heads of drainageways, around slight depressions and on slightly concave footslopes. Permeability is moderate in the overlying medium-textured material and very slow in the underlying fine-textured material, resulting in a seasonally perched water table. Slopes range from 2-15%. The mean annual temperature is 16°C and annual precipitation ranges 625-800 mm.

Thabana Series--Vertisol. Deep, well-drained, slowly permeable soils formed in the weathered products of basalt colluvium and residuum (Fig. III-D-3). These soils are in the heads of drains, along drainageways and on concave sideslopes and footslopes. They are characterized by very dark colors and a high clay content in the surface layer and subsoil. Slopes range from 2-15%. Annual temperature is 13°C and annual precipitation ranges 750-950 mm. Thabana soils are extensively cultivated. Maize, sorghum, beans, squash, and peas are the most common crops. They are widely distributed in the foothills and lower mountains; they are inextensive in the mountains and moderately extensive in the foothills.

Tumo Series--Alfisol. Deep, well-drained, permeable soils formed in the weathered products of basalt residuum. These soils are on ancient plantation surfaces and have slopes ranging from 2-15%. They are characterized by old accumulations of organic matter in the upper part of the soil profile. Annual temperature is 13°C and annual precipitation ranges 800-950 mm. Tumo soils are extensively cultivated. Maize, wheat, beans and peas are the most common crops. They are widely distributed in the western foothills.

Table III-D-6 summarizes information on parent material, distribution, and chemical properties of Benchmark soils. Base saturation, cation exchange capacity (CEC), and total exchangeable basis (TEB) are all important chemical properties relating to soil fertility. However, evaluation of two important nutrient elements in Lesotho, N and P, is not included here.

2. Soil Erosion and Soil Conservation

The very visible dongas (gullies), mostly in the lowland region, are an unpleasant reminder that erosion is a major problem in Lesotho. The two topics--erosion and conservation--cannot realistically be separated. There is little point in the study of soil erosion unless remedies are considered, but an intelligent approach to soil conservation depends on an understanding of the basics of soil erosion and the factors contributing to it. Rooyani (1982) summarized the problem of soil erosion in Lesotho.

"Today soil erosion is a serious problem in Lesotho. We believe that the acceleration of soil erosion in Lesotho, to a large extent initiated during last century is due to three major historical and social developments:

"--Migration and settlement of more people in a geographically confined zone. The population distributed unevenly in the mountain zone and the strip of lowland zone. About 80% of the population gradually centered in the lowland and foothills which constitutes only 30% of the area of the country.

"--Introduction of wheat and maize to the area. The area was naturally a grassland and has low potential for intensive cultivation. Cauley (1986, Personal communication) does not agree that the

Figure III-D-2. Sephula, a fine sandy loam underlaid by a clay loam, is a typical Duplex Soil. Note the light-colored E horizon just above the abrupt change in texture.

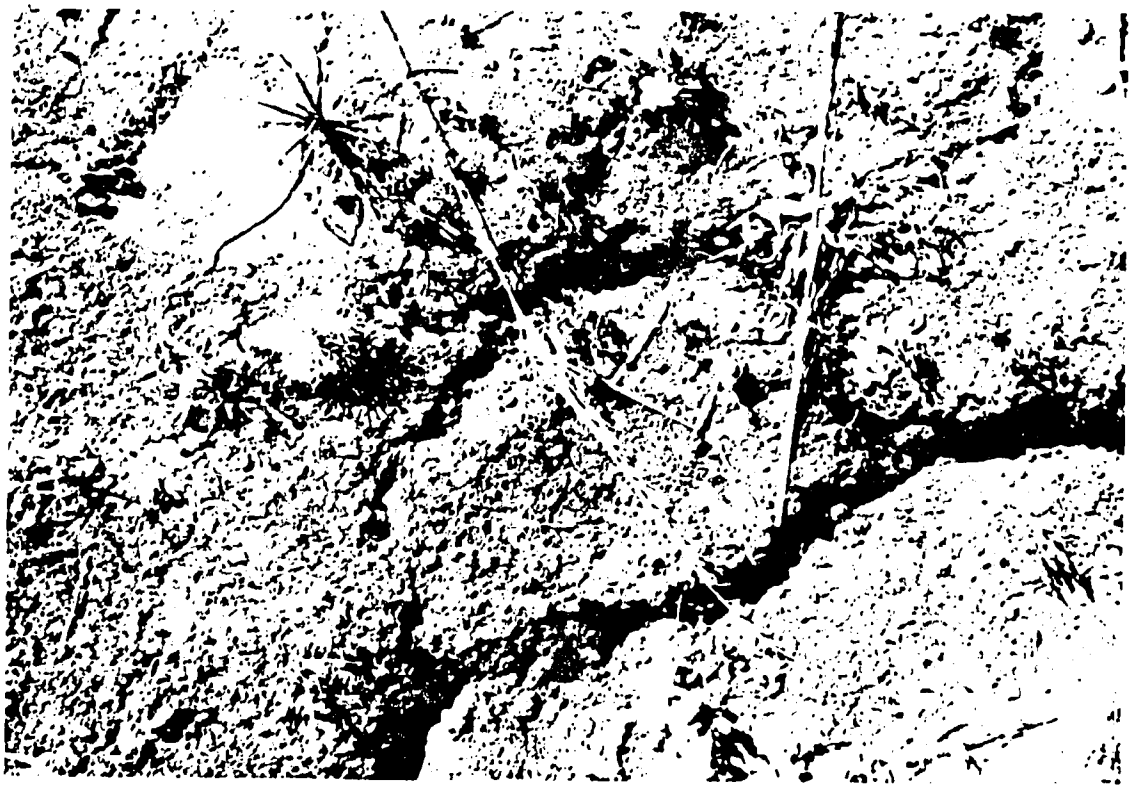

Figure III-D-3. Thabana silty clay is a Vertisol in the foothills region.

Table III-D-6. Parent material, distribution, and some chemical properties of Benchmark Soils of Lesotho (topsoil).

Soil series	Parent material	Distribution	Base saturation (%)	CEC[1] (meq/100g)	TEB[2] (meq/100g)
Fusi	Weathered basalt	Lower mountain and foothills	94	50.4	47.3
Khabos	Allevium basalt	Lowlands	95	19.7	18.7
Leribe	Allevium basalt	Lowlands	51	5.3	2.7
Machache	Basalt	Foothills	46	17.3	7.9
Matela	Basalt & sandstone	Lowlands	63	2.7	1.7
Qalaheng	Weathered sandstone residuum	Lowlands	59	2.9	1.7
Rama	Basaltic alluvium	Lowlands	65	3.4	2.2
Sefikeng	Basalt	Foothills	18	13.6	24.0
Sephula	Shale residuum	Lowlands	90	6.3	5.7
Thabana	Weathered basalt	Lower mountains and foothills	98	60.0	58.8
Tumo	Weathered basalt	Foothills	32	7.5	2.4

1. Cation exchange capacity.

2. Total exchangeable basis.

Source: Cauley, 1986.

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potential for intensive cultivation is low. He indicated that the management level must be defined.

"--The beginning of large scale regional mining activities in Southern Africa.

"Ecologically Lesotho is a grassland country. The natural equilibrium that existed in this grassland ecosystem was disrupted during an ecologically short period of time due to the above mentioned developments and their consequences.

"The lowland zone having some unstable soil and geomorphologic surfaces became the center of urbanization activities. In addition, thousands of hectares of land were farmed and ploughed following the introduction of maize and wheat. The productive rangelands of the mountain zone were subjected to heavy grazing by increasing numbers of livestock. An attractive market for food encouraged the people to put more pressure on land and bring more land (mainly in the lowland) under cultivation in order to produce more for the market. In parallel to these developments, another process started to manifest itself, which was the beginning of a gradual increase in temporary migration of active manpower to the mining areas.

"Pressure on unstable land systems in the lowland, shortage of active manpower at farm level to take care of the land, and intensive single cropping of introduced species by originally pastoral communities formed a chain of events which occurred during a short time which affected the land adversely, exhausted the resources, and ultimately destabilized the ecosystem. The destabilization aggravated during the present century was mainly due to geopolitical confinement of the country and its economical consequences. The best manifestation of a destabilized ecosystem is soil erosion which is the natural response of the system to the external pressure beyond its production level.

"Time is running out but the chance to overcome the problem still exists. The erosion problem in the mountain and lowland zones (excluding the Duplex Soils) can be combated through land management and educational extension activities. Given the geopolitical and economic limitations, a national awareness, will and hard work at all levels of the population are the prerequisite to a successful erosion combating program.

"Technically a national land-use plan will assist to identify the limitations and potentials which will bring about a safer land use than present. Introduction of range management and crop management techniques through intensive extension works will help ensure the proper use of land.

"A national awareness about erosion and its socioeconomic consequences at the farming community level will create the will to combat the problem. Encouragement of the farmers to spend more time on their land and creation of a gradual downward trend of migration will ensure the presence of a willing manpower to take care of the land.

"Management of Duplex Soils falls into a different category. A detailed soil survey should be done in order to delineate these soils accurately. Once they are identified geographically, a careful management plan for their use should be drawn".

"Some Duplex Soils (mainly those with Sodic tendency) may need to be excluded from cultivation. A shift in land use from cultivation to permanent grassland seems necessary for these soils. The good management of these soils at LAC farm is evidence to the fact that prevention of gully formation and controlling of the existing gullies on highly erodable Duplex Soils (non-Sodic) may be used for cultivation provided that proper cultivation techniques (crop rotation, minimum tillage,etc.) are implemented."

a. Soil Erosion

Although the dongas are very visible, it is important to note that gully erosion is a small part of the total problem. Rill erosion, which leads to gullies, is also a cause of serious soil loss, but even more important is the sheet erosion, mostly in the uplands and mountains (Fig. III-D-4). Although not as dramatic and not even very visible, the preponderance of soil loss is from rill and sheet erosion.

Figure III-D-4. Severe sheet and rill erosion in the foothills region. Although donga erosion is very visible and dramatic, rill and sheet erosion (area between horses and sheep) are more serious and more extensive.

Evidently, accelerated (manmade) erosion has been occuring for at least 150 years. and was recognized as a serious problem by the early 1900s (Conservation Division, 1979). At present there are 20,00-30,000 dongas in the lowlands of Lesotho.. Most of these are not of recent origin, although no doubt many of them widen and deepen with time. Donga formation seems to be related to factors far more important than simply poor soil management, although no doubt soil management is a factor. According to Seckler (Conservation Division, 1979), a certain combination of climatic factors is a major factor: a prolonged drought when vegetative cover is severely stunted and ground cover is not complete, followed by a very heavy rainfall period lasting for 2-3 months.

Evidently, this happened in 1932-1933 and the results were disastrous in terms of donga formation. But the soil loss, concurrently, from sheet erosion was probably many times greater. Most of the dongas in Lesotho are probably at least 50 years old. "The overgrazing related to the drought and the cultivation across natural drainageways were probably the major factors in creating the gully system. The continued overgrazing, particularly of the Cave Sandstone mesas and the consequent floods have caused many donga heads to reach the sandstone escarpment" (Conservation Division, 1979).

It appears to some observers that, in general, donga formation is now in a state of short-term equilibrium, although this seems to be a subject of some debate. In any case, one has to question where the extra heavy sediment load in streams and rivers is coming from. According to Seckler and Nobe (1978), the major sources of sediments are:

- sheet and rill erosion on crop and rangeland,
- gully erosion from bank sloughing, and
- roads, trails, and construction sites, especially in villages.

In summary, it may be said that:

- while the dongas are dramatic reminders that serious erosion is taking place (Fig. III-D-5), by far the worst erosion is rill and sheet erosion, separate and usually upslope from the areas of donga formation;
- an overriding factor in the gully erosion problem is climatic, i.e., prolonged serious drought followed by a period of very heavy rainfall; and
- management practices such as overgrazing and overcropping on soils which should have a minimum of cropping or grazing are devastating.

Rooyani (1982) discusses to what extent natural and/or manmade actions contributed to erosion. He makes an interesting comparison between erosion in the mountains of Lesotho and erosion in the lowlands indicating that causes and effects are distinctly different:

- Rain, snow, and colder temperatures are more extreme in the mountain zone. Climate, of course, has a profound effect both directly on the parent material and indirectly through the amount and nature of vegetation, which in turn affects soil formation.

- The geological formation of the mountain zone is igneous (basalt), while the lowlands are sedimentary (sandstone).

- The dominant vegetative type in the mountain zone is grassland "whereas in certain areas of the lowland zone a previous dominant vegetation of deciduous trees is more plausible" (Rooyani, 1982). Thus, nearly all the mountain soils are Mollisols, whereas many of the lowland soils are Alfisols and were probably developed under deciduous trees or shrubs. However, all lowlands soils are not Alfisols. There are some Inceptisols, Mollisols, Entisols, and Vertisols.

In the mountain zone, soil erosion is mostly surface wash (sheet) and rill erosion, primarily as a result of overgrazing. "The erosion problem in the mountain zone is a man-induced phenomenon and recovery of not-badly eroded areas can be achieved quickly through the implementation of sound range management techniques.....Surface wash and rill erosion....in the lowlands are also man-caused and are more harmful to agriculture than gully erosion, even though gully erosion is much more visible" (Rooyani, 1982).

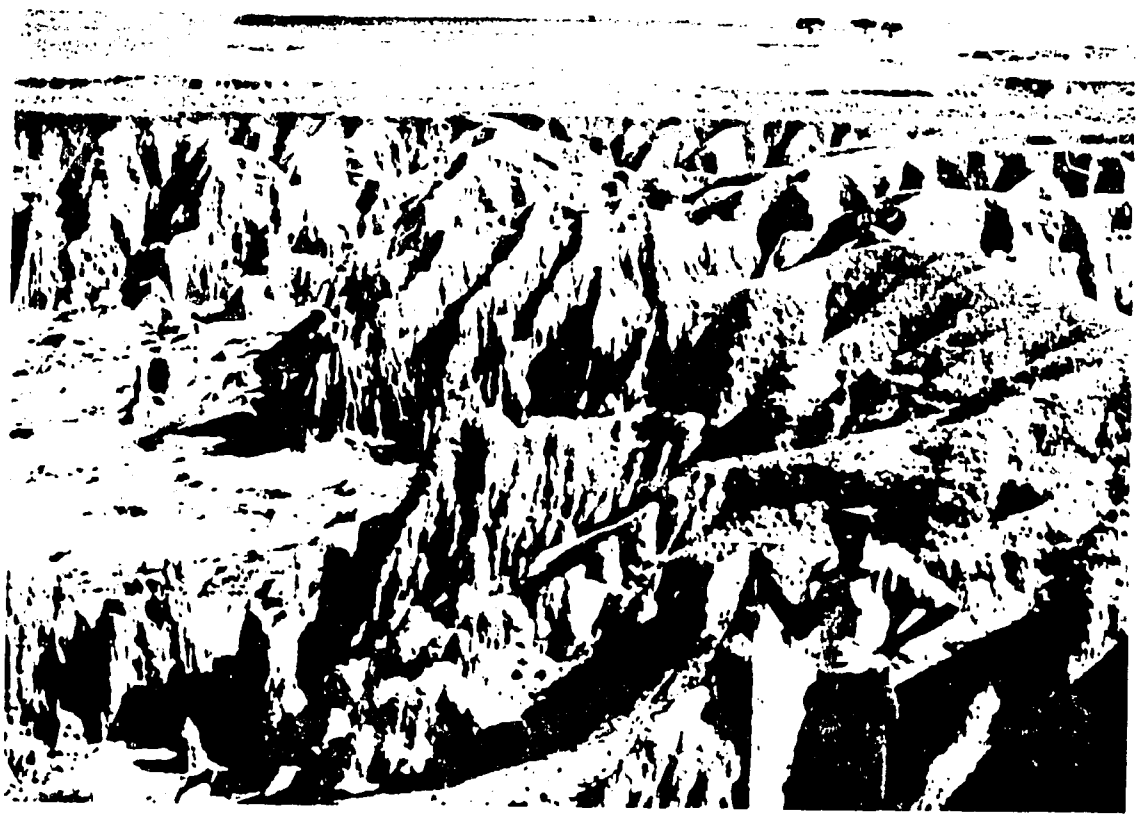

Figure III-D-5. Many years of severe gully erosion in the lowlands produce the "badlands" of Lesotho.

According to the Conservation Division team (1979), gullies affect approximately 15,000 ha or 0.5% of the land of Lesotho. Five soil series in the lowland zone covering about 75,000 ha, 6% of Lesotho and 19% of the lowland area have been rated as easily erodable (Table III D-7). These Alfisols have unique properties and problems that make them Duplex Soils, however gully erosion is not limited to these soils.

Flannery (Rooyani, 1982) estimated that 25% of the 400,000 ha under cultivation are badly eroded and that 7% of arable land has been lost to gullies. He also concluded that there are about 25,000 gullies in Lesotho of which 90% are active.

The Conservation Division team (1979) has taken a much more conservative view, even to suggesting that the gullies are generally stable and are waiting for another severe drought followed by heavy rains.

Rooyani (1982) sums up the causes of gully erosion on Duplex Soils. Two sets of factors are involved:

- The major cause: presence of an unstable medium such as Duplex Soils, that under undisturbed conditions, gradually change toward equilibrium. The instability is related to natural forces of climate and inherited properties of the soil.
- The accerated cause: improper land use that interrupts the slow evolutionary process and intensifies the instability.

Table III D-7. Hectarage of the major Duplex Soils in Lesotho.

Soil series	Total coverage (ha)	% of the area of lowland zone[1]	% of the country
Maseru	20,482	2.25	0.67
Patsa	29,960	3.30	0.98
T'Sakholo	80,097	8.81	2.62
Sephula	42,188	4.64	1.38
Tsiki	2,751	0.3	0.09
Total	175,478	19.3	5.74

1. The area of the lowland zone is considered 30% of the country.

Source: Conservation Division, 1978.

The major cause of gully erosion is the extreme instability of Duplex Soils. Some workers believe gullies would have been formed if there had never been cultivation or overgrazing of these lands (Cauley, 1985). In any case it seems clear that only slight disturbance by man was sufficient to further upset the delicate balance leading to increased erosion (Fig. III-D-6).

b. Soil Conservation

Soil conservation has been practiced in Lesotho for approximately 50 years, mainly with contour banks and grass strips. Recently these works have been upgraded by the addition of grassed waterways and diversions, but these are not the complete answer. Contour banks or graded terraces will prevent the formation of dongas but will not stop the sheet and rill erosion between the banks.

It is generally conceded that it is neither reasonable nor practical to hold erosion to zero, especially since even geologic erosion is not zero. In general, the objective is to hold erosion losses to some specified level, e.g., 5 or 10 t/ha. In striving for such a goal, according to Seckler (Conservation Division, 1979) three concepts need to be addressed: watershed management, vegetative control, and land use capability.

Watershed Management. Any conservation treatment should be considered in relation to entire watershed or drainage area. A total, integrated effort is essential. Vegetation is important in the watershed approach which emphasizes land treatment rather than structures.

Vegetation Control. Man-made increases in erosion and runoff result from imbalance between vegetative cover and the soil-climate-landform conditions. Therefore, the most effective treatment of accelerated erosion is the restoration of a proper balance between vegetation and the site conditions. Some depletion of vegetation through grazing (or cropping) may result in very little change in erosion or runoff until a critical density is reached, after which they will increase at an accelerated rate. This means the land can be used, but the critical point must be known and avoided.

Land-Use Capability. Every unit of land has a specific capability for use without permanent damage. LUC is an expression of the physical land condition, including climate, on the total suitability for using land without damage. If land is used beyond its capability, natural relationships are unbalanced resulting in runoff and erosion.

A quantitative approach to the soil erosion/conservation problem has been developed over the years with reasonable success. This is the Universal Soil Loss Equation. USLE is expressed as follows:

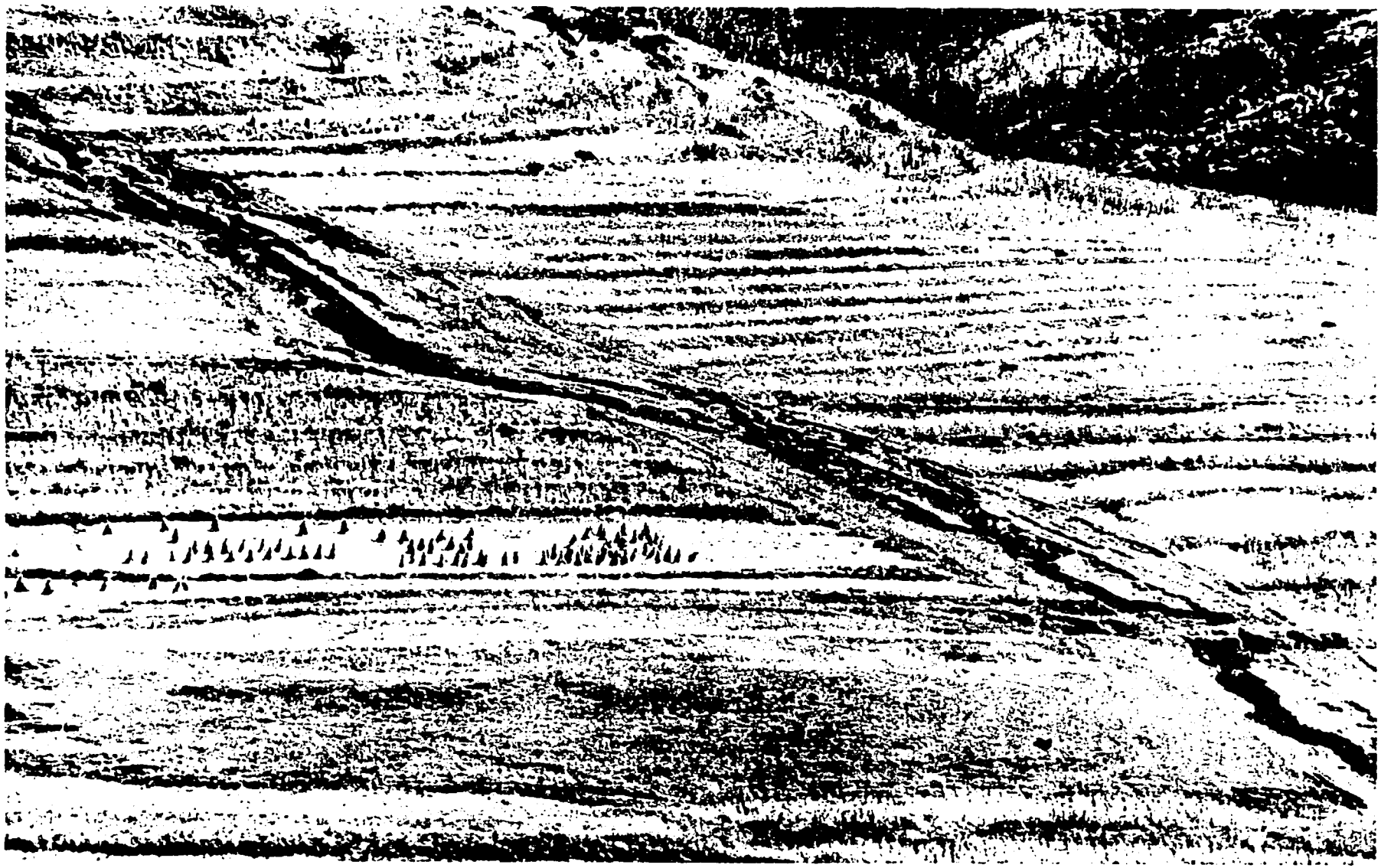

Figure III-D-6. Cultivation of slopes without proper terracing can be one factor in gully formation.

A=RKSLCP

Where: A=Soil loss per unit of land
R=Rainfall
K=Soil Erodibility
SL=Slope length and gradient
C=Cropping
P=Erosion Control Factor

An adaptation of USLE in South Africa, SLEMSA, is being tested in Lesotho. Further treatment of quantitative approaches to soil erosion control is beyond the scope of this paper.

3. Soil Fertility Management

a. Fertility status of Lesotho soils

Lesotho soils are frequently low in N and very frequently low in P. When both are encountered, P is usually more deficient than N. A few low K soils have been found, but they are rare. Mo and Zn are reported to be needed on occasion. Many soils have low pH and some are very low--as low as 4.0 in some cases. P is believed to be "fixed" in these soils and Al toxicity is a problem. The application of lime increases pH somewhat and sometimes increases yield.

A literature review was conducted of fertilizer trials not conducted by FSRP, both before and during the the time of the Project. Eighty trials, mostly on maize, wheat, and potatoes, were conducted over a 25-year period at many locations throughout Lesotho. The details regarding the trials are to be found in several references (FAO, 1975, 1981; Powell et al., 1979; Russell, 1984; Weinmann, 1966, 1968).

Out of 80 trials, 54 responded to N, 70 responded to P, and 6 responded to K. Responses to Mo were reported. In a few cases where Zn and other micronutrients were tested, no responses were reported. Lime applied to low pH soils in a few cases increased the pH, and usually increased yield. These data tend to confirm the general beliefs about soil fertility in Lesotho. In addition, it is likely that the organic matter content in many soils has substantially decreased, presumably because of erosion and intensive cultivation and cropping.

In many cases, responses were obtained at surprisingly low rates of fertilizer, e.g., 40 kg/ha for both N and P. P at these low rates was often applied by banding at seeding time, which in effect becomes a "starter effect".

(1) Soil Tests from Prototype Areas

Prior to planting for the 1984-85 season, soil samples were taken from experimental plots in the three prototype areas. Soil test ranges are summarized:

Area	pH	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)	Total samples
Molumong	6.6-7.5	1.1-8.2	1.4-29	25-500	36
Nyakasoba	4.7-6.7	0.4-9.6	0.3-25	6-335	44
Siloe	5.0-7.3	0.3-1.0	3.6-80	60-162	11

Because of the near absence of soil test correlation data for Lesotho soils, it is difficult to evaluate the fertility levels of the soils represented by these tests except on a relative basis.

Assuming, somewhat arbitrarily, a critical level for P of 30 and, for K, 120, then the following can be said:

Molumong: All soil test P levels are below 30
14 are below 10
14 of 36 soil test K levels are below 120
Nyakasoba: All soil test P levels are below 30
39 of 44 are below 10
10 of 44 soil test K levels are below 120
Siloe: 9 of 11 soil test P levels are below 30
8 of 11 soil test P levels are below 10
6 of 11 soil test K levels are below 120.
Detailed data are shown in Tables III-D-8, III-D-9, and III-D-10.

Table III-D-8. Summary of soil tests, 1984-85 in Molumong prototype area.

Field	Sample no.	pH H_2O	pH SMP[1]	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)
Phuleng	1	6.60	6.87	3.693	4.5	245
	2	6.50	7.11	5.627	14.0	45
	3	7.83	7.28	8.206	8.2	122
	4	6.67	6.91	5.628	14.0	290
SN 1	1	6.59	-	3.788	18.0	300
SN 2	2	7.25	-	4.092	21.0	290
SN 1	1	6.68	-	4.533	1.4	270
SN 3	1	7.02	-	2.173	14.5	132
SN 2	1	7.20	-	1.676	11.0	93
Lilifaneng	1	6.67	6.77	5.803	18.0	500
	2	7.33	7.09	1.055	4.8	117
Mangareng	1	6.80	-	5.351	10.0	267
Letlapang	2	6.62	-	5.260	8.4	175

Table III-D-8 (Cont'd)

Field	Sample no.	pH H_2O	pH SMP[1]	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)
SN 1	1	6.59	-	4.657	10.0	300
SN 1	1	7.40	-	2.658	14.0	85
	2	7.19	-	3.832	3.2	153
Lifofaneng	1	6.55	6.58	6.155	2.1	156
	2	6.36	6.25	7.913	2.5	179
SN 1	1	6.38	-	6.147	5.5	180
SN 1	1	7.17	-	7.700	18.5	90
	2	7.45	-	1.669	4.2	89
Phuleng	1	7.08	-	3.539	14.2	350
	2	6.78	-	6.243	-	200
Phuleng	1	7.12	-	2.781	12.0	200
	2	7.28	-	5.007	6.0	200
Lisema-Thabaneng	1	7.40	7.17	1.875	11.7	92
Phuleng	1	7.13	-	2.287	12.5	86
	2	7.32	-	1.524	11.0	55
Thoteng S1	3	7.40	-	1.347	12.0	99
S2		7.41	-	1.411	28.6	90
S3		7.18	-	3.015	10.0	210
Mabitleng S1		7.10	-	2.373	11.0	95
S2		6.67	-	5.709	26.0	24
S3		6.94	-	2.309	8.1	80
Majakaneng	1	7.18	-	6.508	3.0	200
	2	7.20	-	2.523	2.0	130

1. SMP is a method to determine pH, which predicts lime requirement.

Table III-D-9. Summary of soil tests, 1984-85, Nyakasoba prototype area.

Field	Sample no.	pH H_2O	pH SMP[1]	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)
Thotaneng	S1	4.72	6.10	4.883	0.9	192
	S2	4.65	6.28	5.007	1.1	192
Nokeng	S1	5.40	6.31	6.200	4.7	192
	S2	5.90	6.57	4.700	9.3	192
Mokhoabong	S1	5.82	6.68	5.520	15.2	146
	S2	5.95	6.45	4.373	15.0	212
	S3	5.66	6.24	7.009	7.0	135
Khohlong	S1	5.63	6.75	2.905	1.0	180
	S2	5.25	6.14	3.780	2.1	190
SN 1		4.80	6.30	4.133	6.0	335
Mohlakeng	S1	6.20	-	3.170	5.0	123
	S2	5.99	-	7.294	0.6	97
	S3	6.41	-	3.029	0.2	100
Nqope		4.65	6.28	4.883	0.9	6
Molomoa	1	5.49	5.89	7.017	3.5	142
	2	5.10	5.70	4.557	1.5	117
SN 1		6.00	6.31	6.770	7.0	182
HaMokela	S1	6.18	-	6.346	3.8	163
	S2	5.79	7.17	0.430	5.8	118
Mohlakeng	S1	5.23	5.69	5.600	2.9	192
	S2	5.42	5.82	9.600	11.3	102
Mohlakeng	SN1	6.37	6.95	4.141	0.3	192
	SN2	5.80	6.57	6.552	1.0	128
Khohlo-li-moria	S1	5.47	6.88	2.990	1.1	145
	S2	5.34	6.39	5.160	1.8	192
	S3	5.29	6.35	5.710	1.8	153
Pela Mila	S1	5.21	6.07	5.991	25.0	322
	S2	4.97	6.37	3.400	2.4	190
Lehloka	2	5.35	5.82	9.149	0.3	6

(2) Soil Tests on Benchmark Soils

A number of laboratory tests were made on the Benchmark soils (Table III-D-11).

b. Fertilizers in Lesotho

In Lesotho, most fertilizers are very low analysis. A typical application rate is expressed as:

4 pockets of 2-3-2 (21) per ha
which means:

1. A pocket is 50 kg; 4 pockets = 200 kg.

2. 2-3-2 is the ratio; 21 is the % total nutrients

Table III-D-9 (Cont'd)

Field	Sample no.	pH H_2O	pH SMP[1]	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)
Mokoma	1	6.74	-	1.302	3.2	131
	2	5.64	5.86	3.702	2.2	180
	3	5.30	5.15	4.000	2.9	192
	4	5.15	6.86	3.544	1.5	199
Nokeng	S1	5.33	6.33	5.687	0.6	160
	S2	5.50	6.12	9.106	7.0	126
Tsehlo		5.38	6.06	4.018	1.0	6
Khubetsoana	S1	5.55	6.34	5.52	5.0	190
Mohlakeng	S1	6.20	-	3.170	5.0	123
	S2	5.29	5.64	5.893	2.9	200
	S3	6.41	7.00	3.029	1.7	100
Molibeli	S1	4.67	5.63	6.837	13.0	188
Tsoanyane	S1	5.91	6.15	5.511	4.0	138
Mabathoana	S1	6.07	6.71	4.133	2.0	157
	S2	6.72	-	2.156	0.0	87

1. SMP is a method to determine pH, which predicts lime requirement.

3. A simple calculation reveals the fertilizer is 6-9-6 as % of N, P, K (not P_2O_5 and K_2O).

4. Therefore (x 200 kg/ha) the application rate is 12 N, 18 P, and 12 K on a kg/ha basis.

The system is cumbersome and very difficult to explain to field extension agriculturalists, let alone to farmers. It is essential that a research worker be able to separately apply N, P, and K in field trials so that the element(s) responsible for a yield response are identifiable. It is essential that in educational programs extension workers be able to separate the elements when teaching about crop responses to N, P, or K, not responses to "fertilizer"; also the properties of N, P, and K in soil and their functions in plant nutrition.

A change is essential for progress in research, extension, industry, and in general, for good soil management. The following change can be done gradually and step wise:

Table III-D-10. Summary of soil tests, 1984-85, Siloe prototype area.

Field	Sample no.	pH H_2O	pH SMP[1]	OM (%)	P (Bray 1) (ppm)	K (1N NH_4OAC) (ppm)
Thoteng	S1	5.65	7.42	0.81	19.0	87
Thoteng	S1	5.56	7.37	0.30	4.3	93
Thoteng	S1	6.38	-	0.60	6.2	143
Tsimo Kholo	S1	6.40	-	0.69	43.0	126
	S2	7.30	-	0.53	3.6	162
Thoteng	S1	5.23	7.01	0.53	4.0	127
Lebenkeleng	S1	5.64	7.36	0.15	5.0	66
Lebenkeleng	S1	5.58	7.30	0.37	7.4	60
Lithoseng	S1	5.18	7.21	0.97	9.3	114
	S2	5.72	7.26	0.30	80.2	105
LaMoeletsi	S1	4.97	7.25	0.37	5.6	155

1. SMP is a method to determine pH, which predicts lime requirement.

Table III-D-11. Nutrient status of Benchmark soils of Lesotho (top 30 cm depth).

Soil series	pH Water	pH SMP[1]	Organic matter (%)	Available N ppm	P (Bray-1) (ppm)	K (1N NH_4OAC) (ppm)	EC soil paste extract (mmhos/cm)	Cu HNO_3-$HClO_4$ digestion (ppm)	Zn HNO_3-$HClO_4$ digestion (ppm)	Soil textural class
Berea	5.5	7.2	0.7	8.4	4.5	70	0.2	9	8.5	Sandy loam
Fusi	6.4	0	5.3	11.9	7.6	65	0.3	77	59	Clay loam
Khabos	6.3	-	3.1	3.5	12.8	190	0.4	33	37	Clay loam
Leribe	5.4	6.9	1.1	0	7.8	120	0.3	8.5	13.5	Loam
Macache	5.4	6.4	3.0	0	0.8	272	0.2	59	43	Clay
Maseru	5.9	7.1	0.8	4.2	34.5	80	0.7	4	5.7	Sandy loam
Matela	6.0	7.1	0.9	0	4.7	125	0.3	9	8.5	Sandy loam
Rama	5.8	7.1	0.7	0	5.0	110	0.2	4.7	9.5	Sandy loam
Sefikeng	4.4	5.7	2.7	0	4.6	91	0.3	40	35	Clay loam
Thabana	6.2	-	6.5	5.6	3.0	130	0.5	70	84	Clay
Tumo	4.8	6.1	1.7	0	5.4	194	0.2	29	34	Clay loam
required levels for most crops	6.5-7	lower than 6.9 needs lime		3	20	30-35	160	0-2	2-4	8-15

1. SMP is a method to determine pH, which predicts lime requirement.

Source: Badamchian, Research Division Soil Laboratory.

Year 1. Replace pockets with kg

Year 2. Discard ratio; replace with %, e.g., discard 2-3-2 (21); replace with 6-9-6 (% N, P, K)

Year 3. Allow for increased use of simple fertilizer, as treble superphosphate and KCl

Year 4. Allow for sale and use of high analysis fertilizers.

Adjustment will be slow, and will require an educational program, but while the program is not insurmountable, the solution is predicated on the willingness of South African fertilizer manufacturers to relabel bags.

c. Soil Testing Lab

A properly equipped lab with well-trained personnel, including a qualified supervisor, are essential for a soil testing lab that is intended to serve the needs of agriculture. The purpose is to assist farmers in diagnosing problems and to predict fertilizer needs. This can be done directly by analysis of farmer samples, and indirectly by running research samples as a special service. Normally analyses are made on plant as well as soil samples in a soil testing lab.

The Research Division lab has been directed by Dr. Behjat Badamchian since September 1984. The following section paraphrases Badamchian et al. (1986). The Soil Laboratory has four major activities: services, research, teaching and training, and publications.

About M170,000 was spent on the Soil Laboratory, most to add new equipment and chemicals, and to remodel. Currently, these analyses can be conducted: total and available nitrogen and phosphorus, total and extractable potassium, total zinc and copper, organic matter, pH (different methods), SMP pH and lime requirement, soluble salts, soil moisture content, bulk density, and texture analysis.

It is anticipated that the LAPIS project will continue to upgrade the Soil Laboratory.

More than 8,000 analyses have been carried out and recommendations for both fertilizer and lime requirements made. Most of the samples were from the three prototype areas (III-D-12). The rest of the samples were collected from individual farmers (from all over the country), MOA divisions, and almost all the on-going agricultural projects in Lesotho.

In December 1985 the Soil Laboratory began greenhouse fertility research, to look for phosphorus and lime interaction on Machache soil series and availability of nutrients (especially phosphorus) to maize under different rates of lime and fertilizer. This study will also establish correction measures of pH in Machache series and its

economical aspects. Using similar treatments (three levels of lime and four levels of fertilizers), pots containing Machache soil were limed for cabbage in greenhouse. In addition 24 plots of cabbage and 24 plots of maize were established and limed in Nyakosoba.

The soil series under research trials in the three prototype areas were identified by a short-term consultant (Mack, 1986). This report is available at Agricultural Research Division Library.

Badamchian assisted in training extension officers, assisted in lecturing in agricultural chemistry courses at LAC, and trained the Soil Laboratory technicians at the Agricultural Research Division and LAC.

One of the important steps that the Research Division has undertaken during the last 2 years is the training of extension agents and farmers in 10 districts. The Soil Laboratory was mainly responsible for training the extension agents in techniques of soil sampling for fertility diagnosis, both theory and practice. Soil sampling instructions along with 60 soil sampling probes (made in the Research workshop), were distributed to extension agents and farmers all over the country.

A publication describing Soil Sampling procedures (Badamchian, 1984) was published and about 1,000 copies were distributed to extension officers, extension teachers, farmers, other Divisions of the MOA, and other interested individuals. Both English and Sesotho versions of this circular are available in the Research Division Library. A laboratory manual of Recommended Soil Test Procedures for Soils of Lesotho (Badamchian, 1984) is being revised.

Table III-D-12. Summary of nutrient status of the soils in the three prototype areas.

Prototype area	Water pH	OM (%)	Available P (Bray 1) (ppm)	Available K (1N NH_4OAC) (ppm)
Molumong	6.1-7.8 average 6.9	1-8 average 4	2-28 average 11	47-500 average 230
Nyakosoba	4 2-7.7 average 5.4	0.4-10 average 5	0.3-28 average 6	87-600 average 194
Siloe	4.9-7.3 average 5.7	0.2-1.9 average 0.6	0.4-80 average 24	55-225 average 115

Source: Research Division Soil Laboratory.

d. Soil Test Correlation

Soil test data cannot be interpreted until the tests are shown to have a relationship with crop responses in the field. As an example, if a soil test phosphorus (STP) value of 8 ppm is obtained from the lab, without crop response data from field trials, the value of 8 cannot be interpreted. But assume five maize trials are conducted from which soil tests, before fertilization, were obtained. The following data are generated:

Soil test P (ppm)	Yield increase due to P (%)
4	42
9	25
15	-1
25	2
40	-3

The data indicate an estimated critical soil test range (CSTR) of 9 to 15. (CSTR is the range of soil test values, above which the probability of crop response is very low and below which the probability of crop response is very high). It can now be assumed that STP 8 is low and the probability of crop response is high. However, data from more trials are required before one can establish with confidence a CSTR.

The executive summary of this section is on pages 56-60. The summary of accomplishments and recommendations is on page 96.

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E. Agronomy

1. Situation: Problems and Constraints

Agricultural production and the quality of rural life are described in the USAID Project Paper (1978), and in some of the early Project reports. Crop production is a critical aspect. Data from the agricultural census indicate that, primarily because of increasing pressure from population growth and other socioeconomic factors, along with severe soil erosion affecting approximately 50% of the cultivated area, grain production had declined from 313,000 t in 1950 to 191,000 t in 1970.

Beckerman (1980), in a listing of objectives, implied the following constraints:

- existing varieties are low-yielding,
- drought is a critical factor at times,
- insects have "totally destroyed" some crops, and
- there is a great need to increase fodder production.

Law (1981) indicated the major constraints were: non-availability of fertilizer, pesticides, herbicides, and pure seed of superior varieties; late-maturing maize and sorghum varieties; frost damage in autumn; widespread nitrogen and phosphorus soil deficiency; lack of adequate draft power; non-use and misuse of fertilizer; untimely and ineffective weed control; and inadequate and variable plant population.

As the Project progressed, experience from both field plot work and work with farmers had clarified some problems by 1983. The following list is largely adapted from the 1982-83 Annual Report (RD-R-35). The list applies both to experimental field trials and to general crop production on farms:

- need for land leveling,
- poor seedbed preparation,
- low soil fertility and poor soil fertility management,
- low-yielding varieties,
- inadequate fodder production,
- inadequate draft power,
- poor weed control,
- inefficient or improper cropping systems,

- grain-threshing problems,
- variable and inadequate plant populations,
- unsuitable or inadequate farm equipment,
- soil erosion, and
- cutworms.

This list addresses only problems that are controllable. There are, of course, a number of constraints over which the farmer has little or no control, such as climate and certain soil properties, e.g., drought and the resulting stress.

The 13 problems listed imply potentially 13 objectives and that the activities should be directed toward solutions to those problems. The annual reports indicate many of these problems were addressed.

Holland, in two reports (1983a and 1983b) drew inferences from the Baseline Survey of 1981, in which 441 respondents from the three prototype areas provided data. In these reports, he listed some of the above problems:

- In many respects, the southern lowlands (Siloe area) seemed to have significantly more crop production problems than the other two areas.
- Draft power was greatly lacking. Only 21% of the families owned two or more oxen. Ownership of planters, cultivators, and harrows was 5-15% with only 4% owning carts. None of the families owned a tractor.
- Labor shortage was a problem for approximately 45% of those who owned fields. Labor shortages placed a serious limitation on productivity because of interference with planting and hoeing operations, resulting in their being done too late or, in some cases, not at all.
- Poor condition of oxen. Of those who owned oxen, 91% felt that this was a problem because there was not enough feed in the winter.
- Farmers' own perceptions of major problems were: lack of inputs (seed, fertilizer, pesticides, equipment), inadequate draft power, labor shortages, and no transportation to haul harvested products. Lack of inputs was largely an attitude of off-farm wage earners who either could not or chose not to invest earnings in the farm.

The 1981-82 FSRP Annual Report (p. 10), also discusses the situation at that time:

- For summer crops, most plowing is done in the spring after the first rains. Given the scarcity of draft power and of ox-drawn implements (and the weak condition of oxen), plowing and planting are generally a single operation. The lack of seedbed preparation results in an uneven stand. Because the spring rains may be late, planting is often delayed. Poor quality seed is used.

- Seed planted is from a previous harvest and is not specially selected, treated, or stored properly. It is almost always of unknown germination. Little, if any, fertilizer is used.

- Farmers plant as much land as possible to row crops. Often the stand is poor, competition from weeds is strong, and they are difficult and costly to control. Weeds are a major problem in row crops.

- Cultivation and early weeding are frequently not done effectively because of lack of equipment and labor. The resulting weed competition can reduce yields 50% or more.

- Grain is not stored properly, nor treated, resulting in severe losses to insects, mold, and other pests.

- Crops which are often unsuitable for an area or soil condition are grown, e.g., maize in Siloe on duplex soils.

- There is little evidence of sound crop rotation practices. No organic residues are returned to the soil, fertility is continually depleted with the consequent reduction in moisture storage capacity.

2. Field Trials

Beginning in 1982, a large number of agronomic field trials were conducted each year to address many of the problems mentioned above in the three prototype areas, at Maseru research station, and the six substations. These involved work on varieties, soil fertility, tillage, seedbed preparation, planter comparison, plant population, seed multiplication, weed control, winter fodder production, and cropping systems. Crops were maize, sorghum, wheat, dry beans, peas, potatoes, lentils, and forage sorghum, plus some "new" crops, such as chickpeas, sunflowers, and soybeans.

For example, in the 1983-84 season, 152 trials were initiated. Of these, 77 were in the three prototype areas, including 28 at Siloe, 24 at Nyakasoba and 26 at Molumong. There were 75 trials established on the various stations, with 47 at Maseru. During the following year, 1984-85, 114 trials were established, 37 on the stations and 67 at the prototype areas: 16 at Molumong, 23 at Nyakosoba, and 28 at Siloe. During 1985-86 year 17 trials were established at Molumong, 25 at Nyakosoba, 25 at Siloe, and 44 at the stations, for a total of 111. As expected, many of the trials established each year were not completed for various reasons, such as drought (especially during 1982-84), inadequate commmunication with those in the prototype areas,

poor seedbed preparation, poor site selection, lack of draft power causing scheduling problems, poor weed control, the human factor (unscheduled harvesting by individuals), lack of suitable farm equipment, and damage from hail, wind, and birds. In some cases, cutworm damage was also a serious problem.

There were no yield data from agronomic trials the first year of the project (1979-80) and, evidently, little data from the second year (1980-81). Although a number of 1981-82 trials were harvested, the data were not available. Since the data from year 7 (1985-86) are not yet available (this will appear in Volume II of this report) data from only three years, 1982-83 to 1984-85 will be reported. Some of the data appearing in the annual reports were difficult to interpret, because of abnormally low yields, extreme variability, etc. Only data judged to be of significant value will be reported here.

3. Maize

a. Varieties

Weinmann (1966) indicated that during 1960-64, average maize plot yields were approximately 1,840 kg/ha, but that some yields were as high as 3,800 kg/ha. The highest-yielding, early-planted varieties were SA4, SA5, SA8N, PL10, and PPX K64. For late-planted varieties, SA200 yielded consistently higher than other varieties. During 1965-68, Weinmann (1968) reported the highest yielders were SA4, SA5, SA11, SA100, and PL10.

Powell et al. (1979) indicated "that most previous maize research is antiquated." They were in the process of testing 12 South African hybrids, 25 cultivars from SARCCUS, and 8 from CIMMYT. Evidently very few of the these varieties were considered sufficiently promising to carry over into a testing program by FSRP after 1979. Russell (1983) reported on data from six varieties at six locations. At the "recommended rate" of fertilizer (105 kg/ha N and 32 kg/ha P)) the following yields were reported (mean of six sites):

Variety	Yield (kg/ha)
Silver King	1510
PNR 473	2350
PNR 95	2270
CG 4141	1930
PPX K64R	1170
SSM 101	1920
LSD (.05)	290

The data show that all varieties yielded fairly well except Silver King and PPX K64R.

1982-83 (FSRP). Nineteen varieties were tested at Leribe (Table III-E-1. The four highest-yielding varieties were PNR 437, 6,550 kg/ha; PNR 493, 4,517 kg/ha; Sabi 48, 4,267 kg/ha; and CG 4141, 3,867 kg/ha. Planting was on 9 Nov 82, harvest on 17 Jun 83. Yields of the remaining 15 varieties ranged down to 1,900 kg/ha. Similar trials at Maseru and TY failed.

1983-84. Maize variety trial at Molumong:

Variety	Yield (kg/ha)
Highland White Flint	1350
American White Flint	1200
SSM	2042

1984-85. Maize Hybrids. Three maize hybrids were compared at the Nyakasoba and Siloe prototype areas:

Table III-E-1. Maize variety trial at Leribe, 1982-83, planted 9 Nov, harvested 7 Jun.

Variety	Color[1]	Yield (kg/ha)
PNR 437	W	6550
PNR 493	W	4517
SA 100	Y	3483
CG 4141	W	3867
Sabi 707	W	3100
Sabi 91	W	3375
Sabi 404	Y	3267
PNR 432	Y	3317
Sabi 49	W	2900
Sabi 727	W	3500
TX 14	Y	2850
Sabi 7200	Y	3167
White Bushman	W	2850
PNR 95	W	3267
PNR 542	Y	3167
SSM 101	W	1900
CCA	W	2650
Sabi 48	Y	4267

Differences were significant at .05 (LSD not indicated).

1. W = White Y = Yellow grain

Variety	Yield (kg/ha) Nyakosoba	Siloe
CG 4141	3,658	2,850
TX 225	3,757	3,245
TX 14	2,104	--
PNR 6427	--	3,601
LSD (0.05)	1,320	NS
Planted	18 Oct. 84	12 Nov. 84
Emerged	5 Nov. 84	23 Nov. 84
Fertilizer (kg/ha)	15N-22P-15K + Zn plus 70N sidedress	

1984-85 Potential Maize Yield Trial, Maseru. The trial was established to determine the potential yield of maize using recommended production practices. Included were four hybrids using two rates of side-dressed N (Table III-E-2).

Yields were exceptionally high with the variety CG 4141. The trial demonstrates very dramatically the potential yield for maize in Lesotho. In only one case (PNR 493) was there a significant increase in yield (.05) from the 190 kg rate over the 95 kg rate. The data on ear size helps to explain the high yields for CG 4141. The number of ears per plot did not differ significantly.

Table III-E-2. Potential yield of four maize hybrids at two rates of sidedress N, Maseru, 1984-85.[1]

Hybrid	N (kg/ha)	Yield (kg/ha)	Ear size (grams)
CG 4141	95	11,529	139
	190	12,226	
PNR 95	95	7,542	99
	190	7,869	
PNR 493	95	5,942	99
	190	8,402	
TX 14	95	6,801	94
	190	7,257	
	LSD (0.05)	1,900	

Significance: varieties at .01, fertilizer NS

1. Planted 7 Dec 1984 at a uniform seeding rate. Harvested 23 May 85. No irrigation. Applied 340 kg/ha of 2-3-2(22) + Zn, at planting time, 5 cm below and to the side of the seed.

1984-85. Maize SARMEIT Cultivar Trial, Maseru. Thirty-six maize cultivars from SARMEIT (Southern African Regional Maize Evaluation and Improvement Trials) were tested. Only two of the cultivars recommended for Lesotho, PPX Z64R and CG 4141, were among the 10 highest-yielding varieties (Table III-E-3).

Summary. Several varieties appeared to have potential for Lesotho. Among them were: CG 4141, TX 225, PNR 6427, PNR 95, and PNR 493. CG 4141 appeared to be the most consistently high-yielding variety.

Highland maize bred on the Thaba Tseka Project was introduced and did fairly well (1,000 kg/ha) in the dry year of 1982-83 (see Section III-C, Farm Management). In 1983-84 average yields at Molumong were 2,706 kg/ha. Highland White Dent is well suited to the mountain region. It is open pollinated so that seed can be saved from year to year. Additional 1985-86 data will be reported in Volume II of this report.

b. Soil Fertility

Background information on soil fertility is reported in Section III-D of this report. In brief, N deficiency is common, but P deficiency is somewhat more prevalent. The data also show that, where a soil is deficient in both N and P, P deficiency is nearly always more severe.

1982-83, Leribe. Various rates and combinations of N, P, and K in 27 treatments were applied. Although yields ranged 1,783-3,550 kg/ha, analysis of the yield data indicated no significant differences (at .05). (Data not shown).

Table III-E-3. The ten highest-yielding cultivars in the SARMEIT maize yield trial. Maseru, 1984-85.

Variety	Mean yield (kg/ha)
(A441-5xE728) (Va26xMo17HE)	2,904 a[1]
R201	2,864 ab
PIVR 6427	2,832 abc
A1525	2,636 abc
TX382	2,556 abc
RS5202	2,246 abc
A1305	2,250 bc
PPX K64R	2,192 c
CG 414	2,156 c
PNR 6405	2,122 c

1. Duncan's Multiple Range Test. Values which do not have the same letter are significantly different at the .05 level.

1984-85, Maize Starter Fertilizer On-Farm Trial at Nyakasoba. Three rates of N-P-K+Zn fertilizer were applied at planting time. The plots were later uniformly side-dressed with LAN at 98 kg/ha N.

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (kg/ha)
0	0	0	2,710
10.5	15.8	10.5	3,912
16.8	25.2	16.8	4,682
		LSD (.05)	1,430

Planted 25 Sep 1984
Emerged 12 Oct 1984

Variety CG 4141
98 kg/ha N uniformally side-dressed

Obviously there was a significant response to the application of starter fertilizer. The yield at the highest rate was 74% greater than that at the lowest rate. The yield from the highest rate was more than four times the average yield in Lesotho.

One cannot conclude from the data whether the responses were from the N, P, K, or Zn, or some combination of these. The objective was to determine the response to varying rates of a "standard" starter fertilizer containing all four of these nutrient elements. The return over the cost of fertilizer was M323 at the middle rate and M562 at the high rate of starter fertilizer. This is a return of M6 for every Maluti invested (Richardson et al., RD-R-57, 1985).

Two trials were conducted involving rates of sidedressed N on maize.

Nyakosoba		Siloe	
N side-dressed (kg/ha)	Yield (kg/ha)	N side-dressed (kg/ha)	Yield (kg/ha)
0	6,544	14	3,570
56	6,529	42	4,145
98	8,088	70	5,023
LSD (.05)	1,360		1,220

Variety:	CG 4141	PNR 6427
Planted:	25 Sep 1984	9 Nov 1984
Emerged::	14 Oct 1984	3 Dec 1984
Fertilized:	30N-45P-30K + Zn plus N Side-dress	18N-24P-18K + Zn at planting plus N Side-dress

The data show a significant response to the side-dressed N and the highest rate produced the most maize, 8 t/ha, over eight times the national average. The highest rate of side-dressed N would return the most money (Richardson et al., RD-R-57, 1985).

c. Maize Weed Control

Early weed control work in maize by Weinmann (1966) showed a yield variance from less than 200 kg/ha to more than 2,400 kg/ha. Hoeing at various dates resulted in intermediate yields. Similar results were obtained in a later trial (Weinmann, 1968). No chemicals were used in these trials.

Data from maize trials (Research Division, 1982) are not surprising or unusual, but demonstrate the serious competition from weeds when they are not controlled or only partially controlled.

Treatment	Yield (kg/ha)
None	200
1 hoeing 2 weeks after planting	1,600
Complete control 1st 4 weeks	1,591
Complete control 1st 8 weeks	2,450
Complete control all season	2,750

1982-83. Weed Wiper Trial, Nyakosoba. A weed wiper is a simple device where a rope wick containing herbicide is wiped across weeds leaving herbicide on the weeds, but not on the crop.

The data clearly indicate the ineffectiveness of the weed wiper method in this instance. The weed wiper functioned properly, but by the time weeds were large enough to treat, competition from weeds was severe. By comparison, hoeing was very effective.

1983. Chemical Weed Control on Maize, Maseru and Leribe. Thirty-two treatments including eight chemicals, alone or in combination, were applied at each of the two locations, using RCB with three replications. Analysis of variance is not shown, but there were wide yield differences.. Check (no treatment) plot yield was very low at Leribe and 0.0 kg/ha at Maseru. Atrazine, Atrazine plus Lasso, and Atrazine plus EPTC treatments gave the best results (Table III-E-4).

Treatments	Yield (kg/ha)
Hoe once	1,873 b[1]
Hoe twice	2,517 a
Wipe once with Roundup	138 c
Wipe twice with Roundup	375 c
Wipe once, Roundup plus Dicamba	54 c
Check	155 c

Variety SA 100 Planted 15 Sep 1982

1. Duncan's Multiple Range Test. Values which do not have the same letter are significantly different at the .05 level.

Table III-E-4. Weed control study in maize, 1983.

Chemical	Active rate (kg/ha)	Yield (kg/ha) Maseru	Yield (kg/ha) Leribe
EPTC	3	333	1686
EPTC	4	101	1943
EPTC	6	458	2102
EPTC + Atrazine	3 + .96	1952	1852
EPTC + Atrazine	3 + 1.44	1881	3072
Atrazine	1.44	833	2298
Atrazine	1.92	1934	2506
Atrazine	3.84	2387	2979
Atrazine + Lasso	.96 + 1.15	2095	2875
Atrazine + Lasso	1.44 + 1.15	1714	2733
Atrazine + Lasso	1.44 + 1.52	2048	2895
Gardomil	1.5	702	1452
Gardomil	2	567	1710
Gardomil	3	833	364
Gardomil + Dual 72 OZ	1 + .75	1920	1352
Gardomil + Dual 72 OZ	2 + .72	649	1745
Gardomil + Dual 72 OZ	2.5 + 1.44	196	1502
Bladex	31 product	1488	1748
Bladex	41 product	1357	2348
Bladex	61 product	829	2055
Basogram + Lasso	.96 + 1.15	54	990
Basogram + Lasso	1.44 + 1.15	212	1221
Basogram + Lasso	2.88 + 1.15	375	1598
Linuron + Lasso	0.5 + 1.15	815	2024
Linuron + Lasso	1.0 + 1.15	589	2038
Linuron + Lasso	2.0 + 1.15	589	1550
Gordomil + Lasso	1.5 + 1.15	750	1631
Gordomil + Lasso	2 + 1.15	446	1488
Gordomil + Lasso	3 + 1.15	440	1407
Gordomil + Lasso	2 + 1.72	1006	1729
Check	--	0	474

Chemical applied:	pre-emergence	28 Oct 82	11 Nov 82
	post-emergence	26 Oct 82	28 Nov 82
Evaluation dates:		3 Jan 83	4 Jan 83

Variety: PNR 473 (both trials)
Weeds: Nutsedge, Pigweed, S. bonariensis, Khaki Bush

d. Plant Population

Over a 6-year period at six locations, Weinmann (1966) compared seeding rates in 90 cm rows resulting in populations of 17,000-37,000 plants/ha. Rates of N and P were also included. Although in most cases N and P increased yields, the effects on plant population were variable and inconclusive, possibly because of fairly low yields. However, there appeared to be a trend for higher yields with higher plant populations.

Some survey data (Russell, RD-R-35, 1983) have shown farmer plant populations in the 18,000-20,000 plants/ha range. Russell compared plant populations of 23,000-48,000 plants/ha at five locations. At recommended rates of fertilizer, average yields increased, from 2,200 to 2,800 kg/ha with an increased population.

In 1984-85, an attempt was made by project personnel to compare plant populations up to 45,000 plants/ha at the three prototype areas. Poor germination, cutworm damage, and frost damage lowered populations below the target plant spacings, thus the trials were not sampled for yield responses. It was recommended that all plant population trials be seeded heavily and thinned to desired plant spacing. Optimum plant population for maize is 30,000-40,000 plants/ha.

4. Sorghum

Sorghum is suitable for Lesotho and has the potential to be an excellent crop primarily because of reasonably high yields even under somewhat dry conditions. It is significant that "sorghum was the only summer crop to show a positive return to farmers' labor in the 1982-83 season" (Holland and Tsiu, RD-R-37, 1984, p.6), i.e., a dry season.

a. Varieties

Weinmann (1966) tested six varieties of sorghum at Maseru during 1961-62 to 1963-64. Highest-yielding varieties (110, 120, 112, and Red Mixed) did not yield much, only 750-900 kg/ha.

According to Powell et al. (1979), "Hybrid cultivars PNR 8311, DC 36, NK 300, and selections from Roma White and Tennant White are presently recommended for Lesotho by the MOA." Apparently, none of the varieties tested in the 1960s (Weinmann 1966, 1968) were seriously considered at the beginning of FSRP in 1979.

Russell (RD-R-35, 1983) tested four varieties at five sites against the local "farmers' variety". Of the four varieties, Roma White, DC 36, NK 190, and NK 283 generally outyielded other varieties. Yields were not impressive at four sites with 1,500-2,500 kg/ha, but NK 283 yielded 5,800 kg/ha at one site, Linakeng.

<u>1984-85 (FSRP)</u>. Evidently, sorghum variety trials were not carried to completion before the 1984-85 season.

Trials were planted in the three prototype areas with PNR 8311, Nyakasoba White, and Siloe Best. Trials at Molumong and Nyakosoba failed because of frost damage. Results from Siloe:

Variety	Yield (kg/ha)
PNR 8311	3,036
Nyakosoba	2,843
Siloe Best	2,589
LSD	NS

Planted 31 Oct 84
Emerged 12 Nov 84
Fertilizer: 18N-24P-18K + Zn at planting
plus 70 N side-dressed

A SARMEIT sorghum cultivar evaluation trial was conducted at Leribe. The varieties were SNK 3349, Bernard Rooi, PNR 8311, RA 811A, GB, CAR. 7660, DC 7660, DC 99, C. 1420, SSK 30, and NK 300. The trial was essentially a failure because of cutworm damage.

A Potential Sorghum Yield Trial was established at Maseru using the best known management practices and four presumably high-yielding varieties:

Variety	Yield (kg/ha)
PNR 8311	3,246
PNR 8469	1,646
PNR 8544	3,225
PNR 8537	2,781

Planted: 7 Dec 84
Harvested: 13 May 85
Fertilizer: 30N-45P-30K kg/ha

In summary, although attempts were made to evaluate sorghum varieties, the efforts produced no definitive data through 1984-85. Yields were disappointing, partly because of bird damage. Siloe Best, a white local selection, has done well, especially in the southern lowlands. A red variety, PNR 8311, has also done well. For the foothills region, another white, open pollenated farmers' selection, Nyakosoba White performed well.

b. Soil Fertility

Soil fertility response data on various crops prior to 1979, including sorghum, are reported in Section III-C (Soils).

1984-85. On-farm sorghum starter fertilizer trials were planted in all three prototype areas. Because of frost injury at Molumong and Nyakasoba, only the Siloe trial was carried to completion. The fertilizer was 2:3:2 (22) + Zn applied at planting time:

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (kg/ha)
0	0	0	1,919
7	10	7 + Zn	2,161
14	22	14 + Zn	3,257
		LSD	1,040

Variety: PNR 8311

The data show a strong response to starter fertilizer at the highest rate. There was no sidedress which undoubtedly explains the low yields.

Sidedress N trials were planted in all three prototype areas but were not sampled because of hail and/or frost damage.

A sorghum fertilizer trial involving four rates of N and four rates of P was planted at Maseru. Plots were harvested, but data were of little value in predicting normal responses to increased soil fertility because of extremely low yields caused largely by bird damage.

c. Weed Control

1982-83. A chemical weed control trial was conducted involving Atrazine, Propachlor and Paraquat, alone or in combination, in 16 treatments (Table III-E-5). Plots were not harvested, but observations were made about the effects on weed growth. There was no observable damage to the crop. Atrazine, at all rates, was effective in controlling all five weed species. Propachlor and Paraquat, alone or in combination, were moderately effective. In general it appears that the best weed control resulted from treatments with Atrazine or Paraquat.

d. Plant Population

Plant population can be controlled by manipulating row spacing (between rows) and/or in-row spacing (between plants in the row). Row spacing should be wide enough to accommodate the cultivator, usually 1 m. In-row spacing is determined by growth habit and moisture availability. Trials were conducted at Siloe in 1982-83 and 1983-84:

Row spacing (m)	Yield (kg/ha) 1982-83	1983-84
1.0	811	1,450
1.5	943	1,225
2.0	1333	1,660

Plant population figures are not given. The data indicate that wider spacing (lower plant population) resulted in higher yields during two dry years. An optimum plant population under these conditions may be 30,000-40,000 plants/ha. Under higher rainfall the

Table III-E-5. A weed control study on sorghum: effects of chemical treatments on growth of five weeds, in sorghum (NK 300), mean of three replications, 1982-83.

Chemical[1]	Active rate (kg/ha)	Weeds[2,3] Pw	L	Pv	N	M
Atrazine[4]	1.92	9.7	10.0	10.0	8.0	8.0
Atrazine[4]	2.4	10.0	10.0	10.0	8.7	8.3
Atrazine	1.92	8.3	8.7	9.7	9.0	9.3
Atrazine	2.4	8.0	9.3	10.0	9.0	8.7
Atrazine	2.88	9.0	10.0	9.7	9.7	9.3
Propachlor[4]	0.96	5.0	5.7	7.0	7.0	6.7
Propachlor[4]	1.92	6.7	8.3	8.3	9.3	10.0
Propachlor[4]	2.88	8.3	9.3	10.0	9.3	10.0
Propachlor + Paraquat[4]	.96+0.48	6.0	8.7	9.7	9.0	9.0
Propachlor + Paraquat[4]	1.92+0.96	7.7	10.0	10.0	9.0	8.7
Propachlor + Paraquat[4]	2.88+1.44	10.0	10.0	9.3	8.7	10.0
Paraquat	0.48	6.3	7.7	7.3	10.0	9.7
Paraquat	0.72	4.0	6.3	10.0	6.3	10.0
Paraquat	0.96	7.3	9.3	10.0	10.0	9.7
Check		0.0	0.0	0.0	0.0	0.0

1. Chemical application: Pre: 24 Nov 82, Post: 13 Dec 82, Evaluation: 5 Jan 83.

2. Pw = pigweed, L = lambsquarters, Pv = puncturevine, N = nutsedge, M = morningglory.

3. Weed control scored on a 0-10 scale: 0 = no weed control, 10 = total weed control. There was no crop damage from any treatment.

4. Applied pre-emergence.

population can be 50,000. It is better to reduce population by increasing in-row spacing than row spacing. There is more competition within the row than between rows.

5. Wheat

a. Varieties

Weinmann (1966) reported on winter and spring wheat varieties. Trials at two locations with 25 varieties and two planting dates began in 1954. The planting dates were late April and early June. Yields were not high. White Spitzkop and Scheepers were the highest-yielding varieties at either planting date, but red Spitzkop also yielded relatively well when planted early. Overall, yields did not differ greatly between early and late plantings, although the four highest-yielding, early-planted varieties yielded 800-900 kg/ha, while the four highest-yielding, late-planted varieties yielded 700-800 kg/ha. Weinmann (1966) also reported on summer (mountain) wheat varieties at Mokhotlong and Machache. Yields were somewhat higher than in the Maseru trial, ranging from 1,200-1,400 kg/ha. Highest-yielding varieties were EK 70, JN 41, MM 54 and WM 18.

Weinmann (1968) reported on a continuation of the wheat variety work, but, beginning in 1964-65, he had replaced some of the earlier tested varieties. In a winter wheat trial at Maseru, there was no marked yield difference between planting dates. The highest yielding varieties were Queen Fan, Red Spitzkop, White Spitzkop, and Klein Wit, all averaging about 1,200 kg/ha. Summer (mountain) wheat varieties were tested at Mokhotlong and Machache. The highest yielding varieties were Betana, Kenya Sokkies, ER 5, and MM 54. In a summer wheat variety trial at Maseru, the best yielders were White Spitzkop and Kenya Sokkies.

Powell (1979) compared three winter wheat cultivars and five fertilizer treatments at three sites: Leribe, Maseru, and Thabana. The three cultivars were Bella, Bethu, and Scheepers 69, the last probably a selection of Scheepers used in early trials by Weinmann. In general, at higher fertilizer rates, Scheepers 69 was the highest-yielding cultivar, with yields over 2,000 kg/ha.

1983-84 (FSRP). Twelve winter wheat varieties from Southern Africa (SARWEIN C) were tested at three locations: Maseru, Machache, and Mafeteng. The four leading varieties were SST 103, SWP 2-29, Scheepers 69, and SST 102, with yields of 1,000-2,000 kg/ha, (Table III-E-6).

In addition, twelve spring wheat varieties (SARWEIN D) were tested at Maseru. The four leading varieties, with yields of 900-1,400 kg/ha, were T4, Gouritz, Palala, and Gamka (Table III-E-7).

1984-85. A winter wheat/triticale cultivar trial was conducted at Maseru with six varieties of wheat and six of triticale (Table III-E-8).

Yields of wheat and triticale were comparable, but there was a somewhat wider yield range for wheat than triticale. Another winter wheat trial was conducted at Maseru with nine varieties in which SST 107 and Scheeper's 69 yielded significantly (.05) higher than all other varieties.

Table III-E-6. Yields of 12 winter wheat varieties from Southern Africa (SARWEIN C) grown at three locations, 1983-84.

Variety	Maseru (kg/ha)	Machache (kg/ha)	Mafeteng (kg/ha)	Average (kg/ha)
SST 103	875	1,982	1,054	1,304
SWP 2-29	786	1,946	982	1,238
Scheeprs 69	1,036	1,161	1,196	1,131
SST 102	964	1,179	893	1,012
Karee	518	1,214	1,250	994
HS 86	804	1,018	946	923
T81/1	750	946	1,054	917
Betta	750	929	1,018	899
Belinda	589	1,393	643	875
Wilge	821	1,000	750	857
T 81/11	1,036	714	786	845
T 79/18	393	1,125	964	827

Table III-E-7. Yields of 12 spring wheat varieties from Southern Africa (SARWEIN D) grown on the Maseru Research Station, 1983-84.

Variety	Yield (kg/ha)
T 4	1,375
Gouritz	1,089
Palala	1,036
Gamka	929
SST 66	804
Liesbeeck	714
SST 44	696
Helene	679
K 20	661
Flamink	571
Wilge	536
Karee	446

New wheat varieties are being tested each year for their adaptability to Lesotho conditions. In Lesotho, spring wheats are generally more productive than winter wheats because of the high rainfall during the growing season. However, the prevalence of the Russian aphid on spring wheat in the lowlands makes this a very risky crop in Lesotho.

b. Weed Control

1982-83. The only weed control study in wheat was done at Maseru. Yields were not measured. Other data, including indices of the effect on the lambsquarters and on the wheat, indicate little or no effect on the lambsquarters except with Bromoxynil + 2,4-D (Table III-E-9). There was no damage to the wheat.

"The major problem with wheat in the high altitude areas of Lesotho is a weed problem with wild oats ... the problem ... can be successfully addressed by growing wheat in rotation with peas that are planted in rows so that they can be cultivated and weeded ... Spring wheat is well suited to the higher altitude regions of the area with potential yields of 1,400 kg/ha" (Holland and Tsiu, RD-R-37, 1984, p. 11).

Any row crop in the high altitude areas will permit good weed control and thus a reduced weed problem in the following wheat crop. Peas and beans may not be as productive as sorghum or maize, but do add a little N to the soil for the following crop, e.g., wheat. The decision on what crop to plant depends on the economic returns, and the planting and harvesting dates of the crops.

c. Mechanical Threshing

In work with combination farmers, Egyptian threshers for small grains were compared with hand threshing. There was a grain saving of

Table III-E-8. Winter wheat and triticale yields at Maseru, 1984-85.

Wheat variety	Yield (kg/ha)	Triticale variety	Yield (kg/ha)
T8/1	1,420	Bgl/M2A	1,370
Scheeper's 69	1,390	1RA-Bgl-B2672	1,360
HIN 134	1,160	Blg/Bgl/x ITax Leo-Liuce	1,360
SST 103	1,150	RAM	1,350
Karee	990	M2A-CN	1,250
Gamka	880	DF99xIRA-Bgl B3482	1,150
LSD (.05)	330		330

Planted 24 May 1984

21% over traditional hand threshing. There is a harvest problem for one of the best wheat varieties in Lesotho, Flamink. Flamink is very difficult to thresh by hand. The Egyptian threshers are not suitable because they are not easily moved from area to area. The Agronomy Section, working with Lesotho Steel Company, helped develop and test a new portable wheat thresher available at a reasonable price. More information is contained in the equipment section of this report, III-E-2-j.

Table III-E-9. Lambsquarters control study on wheat (Scheepers 69), Maseru, 1982-83.

Chemical[1]	Active rate	Lambs-quarters[2,3]	Wheat[3]
Glean	3.5 g/ha	0	0
Glean	7 g/ha	0	0
Glean	12 g/ha	0	0
Glean	15 g/ha	0	0
Glean	17 g/ha	0	0
Glean + 2,4-D	3.5 g/ha + 0.25 kg/ha	0	0
Glean + 2,4-D	7 g/ha + 0.25 kg/ha	0	0
2,4-D	0.5 kg/ha	3	0
Bromoxynil	450 g/ha	1	0
Bromoxynil + 2,4-D	225 g/ha + 0.5 kg	7	0
Bromoxynil + 2,4-D	450 g/ha + 0.5 kg	8.5	0
Dicamba + MCPA	1/16 g/ha + 0.5 kg/ha	1	0
Decamba + MCPA	1/8 g/ha + 1 kg/ha	1	0
Faneron	0.5 kg/ha	0	0
Faneron	0.75 kg/ha	0	
0			
Faneron	1.5 kg/ha	0	0
Basogran	0.96 kg	0	0
Basogran	1.44 kg	0	0
Basogran	2.88 kg	0	0
Check		0	0

1. Chemical application: 20 Sept 82

2. Height: 7 cm

3. Effect on plants scored on a 0-10 scale: 0 = not affected by chemical, 10 = total weed control or total crop damage.

6. Beans

a. Varieties

Weinmann (1966) reported on some work done during 1960-65 on varieties of dry beans at Maseru, Matsieng, and Leribe. In general, highest-yielding varieties were: White Haricot Late, Michigan Pea, Pink Wachter, Khaki Sugar and White Haricot Early, but yields were extremely low.

1982-83. A bean variety trial was conducted at Maseru with 16 varieties. The three highest yielding varieties were Pinto 410, Great Northern 61, and Pinto NW 590. Yields were low--less than 750 kg/ha--because of poor stands and low rainfall. Small White Haricot, a standard variety, yielded only 265 kg/ha.

1983-84. Bean variety trials were established at Maseru and TY with 12 varieties (Tables III-E-10 and III-E-11).

1984-85. Trials of three varieties and two planting dates were established at Maseru and TY.

	Maseru planting dates		TY planting dates	
	29 Oct	6 Nov	8 Nov	3 Dec
Variety	Yield (kg/ha)			
Pinto NW 590	518	1,053	759	1,048
Small White Navy Fleetwood	323	811	506	828
Small White Haricot	148	630	535	623

Table III-E-10. Yield of dry bean varieties at two locations, 1983-84.

Variety	Maseru (kg/ha)	TY (kg/ha)
Pinto NW 590	2027	1,264
Great Northern 61	1697	1,378
Pinto UI 114	1855	1,183
Red Mexican 63	1707	1,243
Red Mexican 59	1583	1,319
Small White Navy (Fleetwood)	1901	926
Great Northern Frontier	1527	1,256
Pinto 410	1697	1,071
Michigan Pea Bean	888	-
Small White Haricot	884	531
Speckled Sugar (Bonus)	603	602
Ethiopian Pea Bean	-	394
LSD (.05)	323	305
LSD (.01)	436	411

The effect of planting date cannot be accurately evaluated because the lower yields from the first planting were due to drought stress and CMR beetle damage rather than the direct effects of early planting. Pinto NW 590 significantly (.05) outyielded the other two varieties in all cases.

Twelve bean varieties were compared at two locations, Maseru and TY (Table III-E-12). There were significant yield differences among varieties at Maseru because of poor stands in some of the plots. The best-yielding varieties at Maseru were Pinto NW 590, Pinto 410, and Small White Navy Fleetwood. Yields of these three were low--just over 700 kg/ha--but were much higher than a "standard" variety, Small White Haricot at 312 kg/ha. At TY, the yield of Pinto NW 590 at 1,143 kg/ha was substantially, but not significantly, higher than that of the other varieties.

b. Soil Fertility

1984-85. Four pinto bean starter fertilizer trials were conducted. Two of the Molumong trials, which received low rates of N--up to 20 kg/ha at planting time--resulted in no significant differences due to treatment. Results of the trials at the other two locations are shown in Table III-E-13.

Table III-E-11. Some characteristics of bean varieties from Table III-E-10.

Variety	Days to 50% maturity	Growth habit[1]	Halo blight[2]
Pinto UL 114	80	SD	12
Pinto 410	80	SD	11
Pinto NW 590	80	SD	11
Red Mexican 59	84	SD	10
Red Mexican 63	83	SD	8
Small White Navy (Fleetwood)	80	SD	12
Great Northern Frontier	79	SD	4
Great Northern 61	80	SD	8
Small White Haricot	94	I	5
Ethipian Pea Bean		I	8
Michigan Pea Bean	94	D	8
Speckled Sugar Bonus	94	I	4

1. D = Determinant, SD = Semi-determinant, I = Interdeterminate.

2. Percent of plants affected.

The data indicate significant responses to "starter" fertilizer at both locations, although because of poor stands, yields were low at Nyakasoba and very low at Siloe.

c. Weed Control

1982-83. A chemical weed control trial on Small White Haricot dry beans was established at Maseru using five chemicals at various

Table III-E-12. Yields of 12 bean varieties at Maseru and TY, 1984-85.

Variety	Yield (kg/ha) Maseru	TY
Pinto NW 590	786 a[1]	1143
Pinto 410	761 a	685
Small White Navy Fleetwood	749 a	559
Pinto UL 114	647 ab	605
Great Northern Frontier	601 ab	692
Great Northern 61	589 ab	783
Red Mexican 63	586 ab	774
Red Mexican 59	523 ab	727
Speckled Sugar Bonus	383 b	553
Small White Haricot	312 b	633
Michigan Pea Bean	261 b	566
Ethiopian Pea Bean	175 b	537
Pinto beans		
NW 590	1163	
UL 114	1319	

1. Duncan's Multiple Range Test. Values which do not have the same letters are significantly different at the .05 level.

Table III-E-13. NW 590 pinto bean starter fertilizer trials, 1984-85.

Nyakasoba Fertilizer applied (kg/ha)			Yield (kg/ha)	Siloe Fertilizer applied (kg/ha)			Yield (kg/ha)
N	P	K		N	P	K	
0	0	0	473	0	0	0	224
30	45	30	688	13	19	13	406
45	60	45	1,105	28	42	28	532
LSD			474				107

rates and combinations, in 20 treatments. No yield data were reported, but a numerical evaluation was made of the effect on the weed species present. The chemicals were Treflan, EPTC, Basogran, Dual 720E, and Fusilade. The most effective treatments against pigweed, lambsquarters, and nutsedge were with Treflan, EPTC, or EPTC + Basogran. Basogran added very little to the effectiveness of EPTC. Schkuhria bonariensis was more difficult to control, but was controlled by the high rate (2.88 kg/ha active) of EPTC (Table III-E-14).

7. Peas and Lentils

a. Varieties

Weinmann (1966) conducted a trial at Mokhotolong comparing two local varieties with eight South African varieties of peas. The two local varieties, Basotho Yellow and Basotho Green at 1,500-1,700 kg/ha, yielded nearly double that of any of the South African varieties and more than double most of them.

1983-84 (FSRP). Lentil variety trials, Maseru (Table III-E-15). There was no statistical analysis of the data. Because of low yields (resulting from poor stand) the data are probably of questionable value. The leading varieties appear to be Precoz, Easton, and Red Chief. In addition, six lentil varieites were tested at two locations (Table III-E-16).

b. Weed Control

1982-83. A weed control trial was conducted at Maseru during 1982-83 (Table III-E-17). The more effective treatments were Terbytryne plus either Fusilade, Dual 720E, or Lasso. Some of these same treatments damaged the peas.

8. Potatoes

Potato research was conducted by the Agronomy Section until the 1984-85 season.

a. Weed Control

1982-83. A chemical weed control trial was planted at Maseru during 1982-83 involving six chemicals, alone or in combination, in 20 treatments (Table III-E-18).

9. Minor Crops

Weinmann tested a number of alternative crops, including soybeans, castorbean, flaxseed, winter fodder cereals, and sunflowers. For details, refer to the two original references (Weinmann 1966, 1968).

a. Chickpeas

1983-84. Single-row entries on two planting dates of both short- and long-duration lines show promise for further investigation. Those planted 18 Oct yielded an average of 1,988 kg/ha while those planted 22 Nov averaged 462 kg/ha (Tables III-E-19 and III-E-20).

Table III-E-14. Weed control study on Small White Haricot, Maseru, 1982-83.

Chemical[1]	Active rate (kg/ha)	Weeds[2,3] Pw	L	N	Sb	Bean damage[3]
Treflan[4]	0.48	8	9	8	0	0
Treflan[4]	0.96	9	9.5	8	0	0
EPTC[4]	1.44	8	9	10	3	0
EPTC[4]	2.16	9	10	10	8	0
EPTC[4]	2.88	10	10	10	10	0
EPTC + Basogran[4]	2.16+0.96	10	10	10	5	0
EPTC + Basogran[4]	2.16+1.44	10	10	10	6	0
EPTC + Basogran[4]	2.88+0.96	10	10	10	6	0
Duel 720E[4]	0.72	0	0	0	0	0
Duel 720E[4]	1.44	7	10	2	3	0
Duel 720E[4]	2.88	10	10	4	3	0
Basogran	0.96	0	0	7	0	0
Basogran	1.44	0	0	7	0	0
Basogran	2.08	0	0	9	0	0
Check		0	0	0	0	0
Fusilade	0.25	0	0	0	0	0
Fusilade	0.5	0	0	0	0	0
Fusilade	0.75	0	0	0	0	0
Fusilade	1.0	0	0	0	0	0
Fusilade	1.5	0	0	0	0	0

1. Chemical applications: Pre: 27 Jan 83, Post: 15 Feb 83, Evaluation: 14 Apr 83.

2. Pw = pigweed, L = lambsquarters, N = nutsedge, sb = *Schkuhria bonariensis*.

3. Effect on plants scored on a 0-10 scale: 0 = not affected by chemical, 10 = total weed control or total crop damage.

4. Applied pre-emergence.

b. Grain/Hairy Vetch Fodder, Maseru

1983-84. Barley-vetch and triticale-vetch were compared with and without fertilizer at Maseru and Nyakosoba. Yields at Maseru did not vary greatly, ranging from about 2,600-3,000 kg/ha, dry weight. Yields at Nyakosoba were substantially increased by fertilization (Table III-E-21).

c. Sunflower varieties, Maseru.

1983-84. Sixteen varieties were tested which yielded 2,700-3,600 kg/ha. Highest yields were obtained from SO 323, SO 324, AS 504, and SO 215 (Table III-E-22).

Table III-E-15. Yields of lentil varieties over a 3-year period. Maseru.

Variety	Yield (kg/ha) 1981-82	1982-83	1983-84
Precoz	880	298	705
Brewer	-	275	677
VW 000437	-	245	-
LC 71198	500	238	-
Easton	1,015	232	709
Red Chief	1,250	166	820
Benuenh	940	152	-
Laird	610	74	240
VW 00054	-	49	249
Planted		14 Sep 82	17 Oct 83
Harvested		10 Jan 83	7 Feb 84

Table III-E-16. Comparison of six lentil varieties planted at two locations, 1983-84.

Variety	Maseru (kg/ha)	Mokhotlong (kg/ha)
Red Chief	820	498
Easton	709	983
Precoz	705	324
Brewer	677	738
VW 000504	249	712
Laird	240	631
CV 7.4%; LSD	NS	435

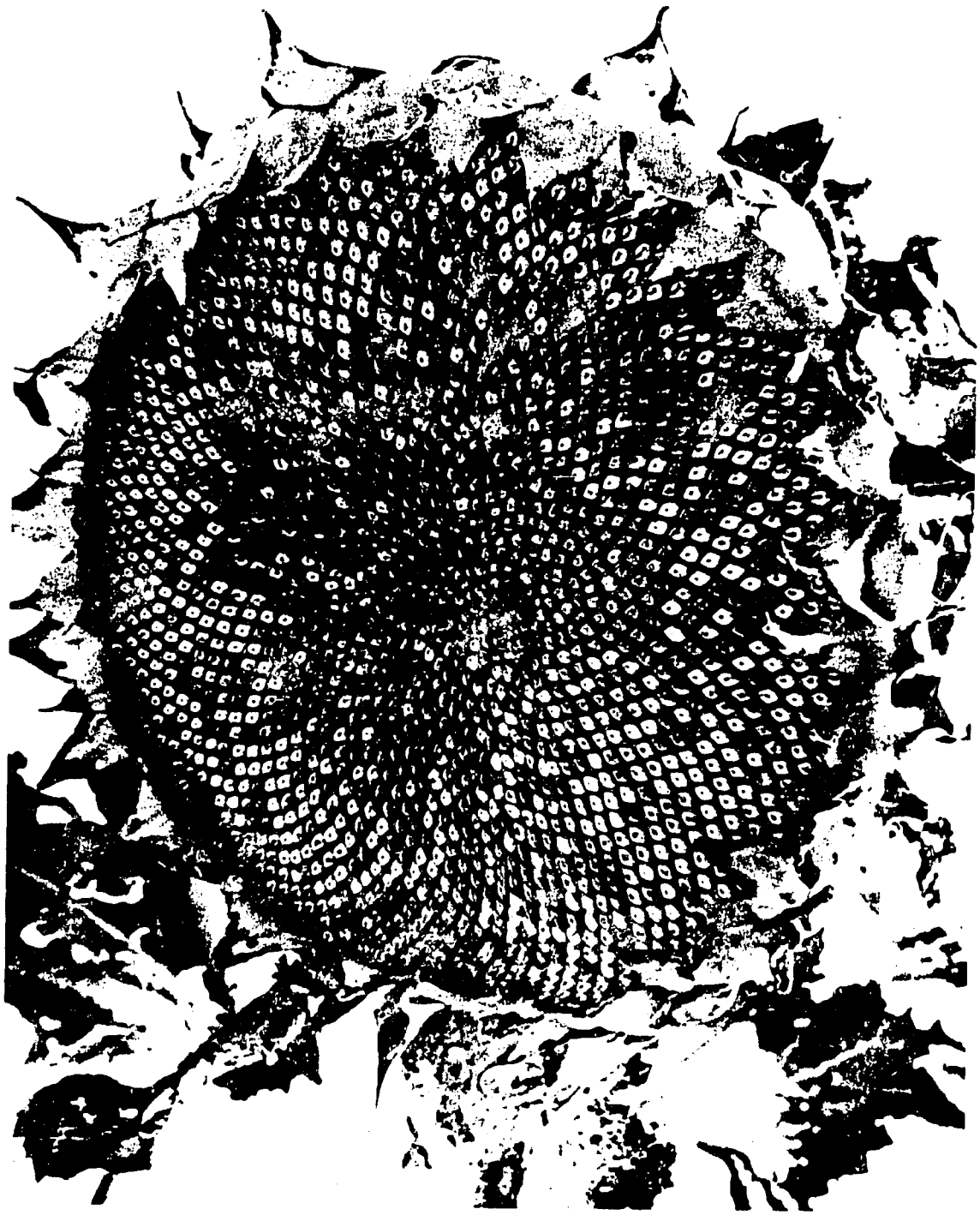


Figure III-E-1. Research Division agronomists tested 16 sunflower varieties. Yields were 2,700-3,600 kg/ha.

Table III-E-17. Weed control study on peas, Maseru, 1982-83.

Chemical[1]	Active rate (kg/ha)	Weeds[2,3] Pw	L	Pv	Pea damage[3]
Terbutryne	1.18	4.7	7.7	0.7	0.0
Terbutryne	1.41	6.3	8.0	2.3	0.0
Terbutryne	1.88	6.3	8.3	2.3	0.0
Terbutryne	2.82	6.3	8.0	2.3	0.0
Terbutryne + Dual 720E	1.41+1.44	7.3	6.0	0.7	0.0
Terbutryne + Dual 720E	1.88+1.44	5.7	8.0	0.7	0.0
Terbutryne + Dual 720E	2.82+1.44	9.7	10.0	5.0	0.0
Check		0.0	0.0	0.0	
Terbutryne + Fusilade	1.4+0.5	10.0	10.0	7.7	7.0
Terbutryne + Fusilade	1.88+0.75	10.0	10.0	9.7	9.0
Terbutryne[4] + Fusilade	1.4+0.5	10.0	10.0	10.0	9.3
Terbutryne[4] + Fusilade	1.88+0.75	10.0	10.0	10.0	9.7
Metribuzin	1/4	6.0	7.0	0.7	1.0
Metribuzin	1/2	9.0	10.0	4.0	1.3
Metribuzin	1	10.0	10.0	8.7	3.3
Basogran	0.96	3.7	3.0	0.0	0.3
Basogran	1.44	3.3	2.7	0.7	0.0
Terbutryne+Lasso	1.4+1.15	10.0	10.0	10.0	9.3
Terbutryne+Lasso	1.88+1.15	10.0	10.0	10.0	9.6
Terbutryne	1.4	10.0	10.0	9.4	1.7

1. Chemical application: Pre: 10 Aug 82, Post: 28 Sep 82, Evaluation 26 Oct 82.

2. Pw = pigweed (6 cm high, 5 plants/m), L = lambsquarters (8 cm high, 4 plants/m), Pv = puncturevine (25 cm high, 3 plants/m).

3. Effect on plants scored on a 0-10 score: 0 = not affected by chemical, 10 = total weed control or total crop damage.

4. Post emergence.

d. Cowpeas

1984-85. In a potential yield trial at Maseru, the variety Tswana was grown without irrigation. The yield was considered good.

Sample no.	Yield (kg/ha)
1	2389
2	2275
3	2822
4	2464
5	2316
Mean	2454

Planted 12 Dec 84 Harvested 1 Apr 85

Table III-E-18. Weed control study on potato, Maseru, 1982-83.

Chemical[1]	Active rate (kg/ha)	Weeds[2,3] Pw	N	Pv	Sb	Potato Damage	Yield (kg/ha)
Paraquat + Lasso	0.25 + 1.92	10.0	5.0	8.0	7.3	0.7	4906
Paraquat + Lasso + Metribuzin	0.25 + 1.15	10.0	6.0	9.7	10.0	4.0	619
Metribuzin	0.75	10.0	7.0	9.3	10.0	0.7	2902
Metribuzin	1.0	9.7	8.7	8.7	10.0	4.0	1008
Metribuzin	1.25	10.0	6.3	7.3	10.0	7.0	150
Metribuzin	1.5	9.7	7.0	10.0	10.0	4.7	528
Metribuzin + Lasso	0.5 + 1.15	10.0	7.3	9.0	10.0	0.0	2931
Metribuzin + Lasso	0.75 + 1.15	9.7	3.3	8.0	10.0	1.7	1481
Metribuzin + Lasso	1.0 + 1.15	10.0	3.7	9.0	10.0	2.7	875
E.P.T.C. (Pre)	3.5	9.0	10.0	8.3	1.0	0.0	2736
E.P.T.C. (Pre)	5	7.0	9.7	5.3	4.0	0.0	2317
E.P.T.C. (Pre)	8	7.0	10.0	6.0	4.3	0.0	3925
E.P.T.C. + Metribuzin (Pre)	3.5 + 0.5	9.7	9.3	9.7	9.7	0.0	2572
Check		0.0	0.0	0.0	0.0	0.0	1661
Linuron	1	6.7	0.0	0.7	2.3	0.0	1903
Linuron	2	8.7	2.0	1.0	7.0	0.0	2886
Linuron	4	10.0	2.7	4.7	8.7	0.0	2475
Linuron + Lasso	0.5 + 1.15	9.3	7.7	1.3	0.0	0.0	2994
Linuron + Lasso	1 + 1.15	8.0	2.7	1.0	4.0	0.0	3850
Linuron + Lasso	2 + 1.15	10.0	4.3	2.0	7.7	0.0	3558

1. Chemical applications: Pre: 29 Sep 82, Post 10 Oct 82, Evaluation 3 Feb 83.
2. Pw = pigwood, N = nutsedge, Pv = puncturevine, Sb = *Solkuhria benariensis*.
3. Effect on plants scored on a 0-10 scale: 0 = not affected by chemical, 10 = total weed control or total crop damage.

Table III-E-19. Comparative yield data, lines of short-duration, Desi-type chickpeas harvested from single row entries, 1983-84.

Line entries (ICC/ICCL No.)	Planted 18 Oct 83 Harvested 7 Feb 84 (kg/ha)	Planted 22 Nov 83 Harvested 15 Feb 84 (kg/ha)
4918	2093	475
5003	1608	520
11529	1720	557
11530	1987	240
12199	2392	448
12333	1733	504
12334	1291	448
11141	2736	563
2375	2021	579
78012	2419	667
78023	1725	208
78055	1797	488
78073	2515	379
79008	2408	235
81018	1552	493

Table III-E-20. Comparative yield data, lines of long-duration, Desi-type chick peas harvested from single row entries, 1983-84.

Line entries (ICC/ICCL No.)	Planted 18 Oct 83 Harvested 7 Feb 84 (kg/ha)	Planted 22 Nov 83 Harvested 15 Feb 84 (kg/ha)
4948	1725	541
10136	1976	461
11514	1189	605
HG-218-6-14	1376	480
HG-202-6-1	2381	565
11508	1938	253
11524	2307	421
79015	2317	400
79037	2333	445
79043	1275	525
79045	2248	445
79063	1613	485
79078	2339	333
79086	1685	701
79092	2493	595

Cowpeas were also grown in an observational nursery in 4-row plots.

Variety	Yield (kg/ha)
IT81D-1137	1838
IT82D-716	2298
IT82D-889	1437
IT82E-9	1768
IT82D-789	1038
IT82E-18	918
IT81D-1064	255
Mean	1268

Table III-E-23 lists the recommended crop varieties for the different areas.

Note: A considerable amount of agronomic work was done in cooperation with the Farm Management Section and is reported in Section III-C. Highlights of the agronomic aspects of that work are in the Executive Summary.

Table III-E-21. Grain/hairy vetch fodder (dry weight) at two locations, 1983.

	Maseru		Nyakosoba
	First cut (kg/ha)	First and second cuts (kg/ha)	One cut (kg/ha)
Barley/vetch mixture	1400	2592	575
Triticale/vetch mixture	1467	2892	358
Barley/vetch mix plus fertilizer[1]	1600	2809	1575
Triticale/vetch mix plus fertilizer[1]	1667	2984	875
Date of planting	16 Mar 83		14 Mar 83
Date of cuttings			
1st cutting	1 Sep 83		
2nd cutting	31 Oct 83		
Single cutting	31 Oct 83		25 Oct 83

1. Fertilizer rate not known.

10. Forage Crops

1985-86. Forage Observation Trials on an Acid P-deficient Foothills Soil. In the foothills region of Lesotho, there are extensive areas with soils of very low pH, often below 5. Along with the P deficiency and potential toxicities, this is a serious constraint to crop production. Correcting the pH with lime is prohibitively expensive, as lime costs approximately M200/t in Maseru. Use of acid-tolerant crops adapted to these problem soils may offer more promise than attempts to change the soils. Because livestock forage is in chronically short supply, an investigation was undertaken to evaluate the potential of several forage species, particularly legumes, on these acid soils.

The objective of this study was to screen the growth and yield of a number of forage species on an acid, P-deficient foothills soil, to observe responses to lime and phosphorus and to observe their adaptability to the foothills climate during the rainy summer growing season.

The plots were planted on an Alfisol (Sefikeng clay loam) at Nyakosoba (elevation 2,000 m), where the mean annual precipitation is 820 mm. The topsoil (0-15 cm) was pH 4.4, and had 4.7% organic

Table III-E-22. Yield comparison of 16 sunflower varieties grown under dry land conditions at Maseru, 1983-84. Row spacing of 90 cm, seeded on 1 Oct 83, harvested on 9 Mar 84.

Variety	Yield (kg/ha)
So323	3568
So234	3502
AS504	3479
So215	3454
AS500	3365
PNR 7204	3254
S604	3163
S606	3105
SO222	3102
HV772	3068
PNR 7225	2992
PNR 2915	2876
S601	2874
PNR 2745	2754
SO171	2690
SO404	2659

LSD 0.05 = 279.6

matter, 15 ppm available N, and 2 ppm available P. On 17 Sep, the field was prepared with a moldboard plow, limed by broadcasting at 0, 2, 5, and 10 t/ha, fertilized (broadcast) on all blocks at 350 kg/ha of 2:3:0(21)+Zn (equivalent to 21N, 32P, and 21K in kg/ha) and disked and harrowed. It was cultivated on 3 Dec, and planted 3-12 Dec with a Planet Jr.

Both monocrop and mixed plantings were made. In monocrops, rows were spaced 30 cm apart and planted across all four lime treatments. In the mixed stands, seven rows of grass were planted at 30 cm spacing

Table III-E-23. Crop varieties recommended for Lesotho.

	Mountains	Foothills	Lowlands
Maize	Highlands White Flint Highlands White Dent	PNR 473 CG 4141 PNR 95 TX 14 (yellow) A305W Silver King Highlands White Dent	PNR 473 CG 4141 PNR 95 TX 14 (yellow) A305W Silver King
Sorghum (grain)	PNR 8311 PNR 8544 G766W Tenant White	PNR 8311 PNR 8544 G766W Tenant White	PNR 8311 PNR 8544 G766W Tenant White
Sorghum (forage)	PNR 989 PNR 536 Trudan Sordan	PNR 989 PNR 536 Trudan Sordan	PNR 989 PNR 536 Trudan Sordan
Beans	Small White Haricot Speckled Sugar Pinto NW 590 Michigan Pea Bean	Small White Haricot Speckled Sugar Pinto NW 590 Michigan Pea Bean	Small White Haricot Speckled Sugar Pinto NW 590 Michigan Pea Bean
Wheat (winter)		Scheepers 69 Flamink Karee Gamka SST 107	Scheepers 69 Flamink Karee Gamka SST 107
Wheat (spring)	Bella SST 102	Bella SST 102	

and then six rows of legumes were planted between the grass rows. All legume seeds were innoculated. Three rows of maize (AX305W, Asgrow Seed Co.) were planted along one edge of the trial, running through the four lime treatments. No sidedress P was added to the maize.

One month after planting, lime blocks were split to no P and P treatments; the latter received a sidedress of 150 kg/ha double superphosphate (30 kg/ha P), applied with a Planet Jr. between every other row.

Species tested were (with yield data):
Red Clover (*Trifolium pratense*) cv. Kenland
Italian Ryegrass (*Lolium miltiflorum*) cv. Midmar
Italian ryegrass/Wooly Pod Vetch
Italian ryegrass/Ladino Clover
Ertagrostis curvula cv. Ermelo/Wooly Pod Vetch
E. curvula/Ladino Clover
E. curvula/Subterranean Clover
Seradella (*Ornithopus sativus*)

(without yield data):
Subterranean clover (*Trifolium subterraneum*) cv. Mt. Barker
Ladino White Clover (*Trifolium repens*)
Wooly Pod Vetch (*Vicia dasycarpa*) cv. Lana

Growing conditions were favorable throughout the season. Rainfall was adequate, no frosts occurred until the end of March, weeds were adequately controlled, insect damage was never severe, but there was some rabbit damage to Ladino White Clover.

Harvest of each crop began at 10-20% flower. A sample was cut from each lime x P plot, and an uncut portion left to monitor continued growth. The experimental design was a split block, split plot with one replication. Yield data were tested using regression analyses.

The maize border rows showed a strong growth response to the lime treatments, indicating the effectiveness of the lime in changing soil properties. Plants showed P deficiency symptoms in the leaves for all lime treatments. At 15 weeks, average plant heights were: no lime and 2 t lime, 80 cm; 5 t lime, 130 cm; and 10 t lime, 170 cm. Only the plants in the last treatment were tasseling and forming ears.

Of the species tested, *Seradella* and *Eragrostis curvula* showed the least response to lime treatment (data not shown). Despite its acid tolerance, *E. curvula* still yielded far less dry matter than the Italian ryegrass treatments at all lime levels. Additional P sidedress gave no yield response and in fact showed a slight yield depression in many cases, particularly on the 2 t lime plots.

From an economic standpoint, every crop showed a net return over fixed costs (seed, lime, fertilizer) at the no lime level, and this level gave the highest return in five out of six cases. Only the

ryegrass/vetch mixture showed an increased return with lime at the 2 t level. The ryegrass monocrop gave the highest return of any treatment, but the ryegrass/vetch mixture was very similar and represents a superior quality feed due to the higher protein content of the vetch.

Assuming it is not economically feasible to apply lime, it is of interest to compare yields of dry matter with the 0 lime and +P treatment for each crop harvested (Table III-E-24).

It is obvious that Serradella, ryegrass, or ryegrass plus a legume far outyielded all others where yields were measured.

The Sefikeng soils apparently can produce good yields of several crops, including forages, if the crops are tolerant of the adverse soil chemical properties. Adequate fertilization is essential. Further research is needed to identify the toxic conditions(s). Aluminum toxicity is suspected, and the 5 t/ha lime rate appears to have corrected the problem. Crops which are sensitive to Al toxicity should not be grown on these soils unless they are high value crops which can generate returns to cover the 5 t/ha lime expense. The longevity of the lime effect in these soils needs to be studied to determine whether the benefit of a lime application may be spread over several years. Initial outlay for liming is beyond the means of most farmers. Selecting adapted crops (and tolerant varieties) and developing appropriate fertilizer guidelines offer the most promise to improve crop production on chese acid, foothills soils.

11. Special Topics

The topics in this section are discussed from research data as well as from experience and close contact with farmer practices.

Table III-E-24. Forage yield trials, Nyakosoba, 1985-86.

Species	Yield, 15% moisture (t/ha)	Net return over fixed costs (no lime) (Maluti/ha)
Seradella (2 cuttings)	6.90	847
Italian Ryegrass	7.27	1271
Italian Ryegrass/Wooly Pod Vetch	7.00	1147
Italian Ryegrass/Ladino Clover	7.30	949
E. curvula/Wooly Pod Vetch	2.73	343
E. curvula/Ladino Clover	2.18	339
E. curvula/subterranean Clover	2.89	359

a. Weather Variation

One of the most serious constraints to crop production is the variability of weather, especially rainfall. The average rainfall in much of Lesotho's cropland is probably just sufficient to grow crops successfully, but rainfall distribution is usually less than desirable. In nearly 50% of years, the yields are below average, and in 25% yields are nearly disasterous.

The unpredictability of rainfall has a number of important implications, three of which are the decision whether to raise sorghum or maize, side-dressing with N, and plant populations for maize and sorghum.

Sorghum vs. Maize. Sorghum is more drought-resistant than maize. Average yields of maize and sorghum are comparable, although potential yields for maize are substantially higher than for sorghum. In field trials, high sorghum yields were 3,000-6,000 kg/ha, while high maize yields were 6,000-9,000 kg/ha. Thus, high maize yields are probably double those of sorghum under optimal conditions.

This may have a psychological effect on the farmer, even in the southern lowlands where maize should not be grown. He or she is encouraged to grow maize because of the high yields once every few years, and because maize is the staple food in the family diet.

Rather than field trials, probably educational programs showing the advantage over several years of staying with sorghum would be effective.

Side-dressing with N. The decision how much LAN or urea to apply as a side-dressing to maize or sorghum is difficult. In wet years side-dressed LAN will have high payoff, but in dry years the investment may be wasted. Farmers should always apply enough N to meet the needs of a crop during an average rainfall year. Since no one can accurately predict the rainfall for the remainder of the growing season, or when it is time to side-dress with N, the farmer should do so. In this way he will on average receive greater benefits than if he tries to predict the weather and varies the program accordingly.

Plant Population. Maize and sorghum plant populations relate to rainfall variability in much the same way as the two examples given above. Plant population studies indicate that under average conditions an optimal population for maize is 30,000-40,000, and sorghum is 40,000-50,000 plants/ha.

In any cropping program it is essential that the farmer consider the probability of rainfall in the area. In some years, and especially in low rainfall areas, the farmer may be prone to reduce the plant population to some point below the estimated optimum for a normal year. However, if he or she consistently reduces plant populations below tested numbers, predicted income will be lost during

half of the years, when rainfall is normal (average) or higher. There is actually little additional cost at higher populations, only a reduced yield during low rainfall years.

Highly variable rainfall patterns are one of the Basotho farmers' worst enemies. Until weather forecasting becomes much more accurate than it is today, the farmer is faced with making decisions based on probability. In some cases it may be wise to choose on the conservative side.

Other elements of weather are subject to the same principle of probability. Important ones are late spring frosts, early autumn frosts and hail. In these cases, the risk can be reduced somewhat by planting on time and by choice of crops. Also some crops are more resistant to frost or hail damage than others.

b. Autumn Plowing

In unreplicated trials at Siloe in 1983-84, the sorghum yield in a field which was plowed in the autumn was 1,436 kg/ha, compared with a spring plowed trial, which produced 1,184 kg/ha. While there are very little data on this practice, observation and experience in working with Basotho farmers have indicated, convincingly, the advantages of plowing in the late summer or early autumn.

The advantages of early autumn plowing are:

- More effective use of a limited number of oxen. By spring oxen are weak and inefficient from having been underfed.
- Moisture conservation. Plowing allows better infiltration of the limited winter rainfall.
- Cutworm control. The reasons for this are not well understood, but the effect is fairly well established. One reason is believed to be that overwintering sites are severly reduced by incorporating crop residues, which decompose.
- Early decomposition of incorporated organic material, resulting in better tilth and early release of nutrients from decomposing organic material.
- The time factor, allowing for early planting. Spring plowing requires that either plowing be done in hard, dry soil, or waiting until after some spring rains before plowing.
- More effective and cheaper weed control

c. Principles of Weed Control

Of all constraints to crop production, weeds rank among the most serious in Lesotho. The effects of weed competition on crop growth and yield are well known, but the weed control trials have

dramatically demonstrated this effect in maize trials. An example:

	Yield (kg/ha)				
	1	2	3	4	5
No weed control	190	200	155	0	474
Weed control	2,466	2,750	2,517	2,387	3,071

Such data, of course, are not surprising or unusual, but they demonstrate the serious competition from weeds that are not controlled. Evidently this kind of demonstration and practice is badly needed in Lesotho. One trial effectively demonstrated the effects of control during different growth periods:

Treatment	Maize yield (kg/ha)
No control	200
1 hoeing 2 weeks after planting	1,600
complete control 1st 4 weeks	1,591
complete control 1st 8 weeks	2,450
complete control all season	2,750

These data relate to the common practice of only partial weed control. Some farmers do not practice weed control because of the potential use of the weeds for livestock feed or human consumption. However, the yield reduction from failure to control weeds early more than offsets the small benefits from the weeds. In many cases, crop failure is the inevitable result. Drought and low soil fertility effects are increased by the presence of weeds.

Of course weeds can be controlled by tilling, hand hoeing, chemicals, or a combination. Tillage and hand hoeing are used, but are often ineffective or only partially effective because of shortages of labor, draft power, and cultivation equipment. The data on chemical control show promise, but chemicals are hazardous and expensive, and the use of herbicides requires considerable training and experience. The general use of herbicides will probably not be appropriate for a few years but, in planning for future programs, this approach should not be discarded.

d. Cropping Systems

Crop rotation, double cropping, green manuring, and cropping for winter feed, food or cash, all have different purposes:

- Crop rotation--to control pests and to spread the risk.
- Double cropping--cropping in winter as well as in summer for more efficient use of a given field.
- Green manure crop--a crop planted to be plowed under mostly for improving or maintaining desirable physical and chemical soil properties. Such a crop may also have been used for another purpose such as grazing.

- Winter feed--winter fodder, especially for oxen, is critical.
- Crops for food or cash--maize and sorghum constitute the bulk of the human diet in Lesotho.

This subject is far too involved to be treated exhaustively, but a review of the important concepts and practices will be of value.

Since food self-sufficiency is an objective of the government of Lesotho, any decisions about choice of crops or cropping systems must consider the major food crops--maize and sorghum. Another important fact is that nearly all the food is consumed by the family which produces it. A very small amount enters the channels of trade. Until these two situations change, research must be done on crops that will meet these needs.

All five of the major crops can be successfully produced in all areas of Lesotho, however, some are better adapted to certain areas than others. Winter wheat is not well adapted to the mountain areas, because of cold temperatures during the winter. In fact, winter production of crops in the mountains is very limited. Sorghum is a better risk in the lowlands than maize, especially on sandy soils, because of its greater tolerance to drought. Spring wheat, although well adapted, is a risk crop in the lowlands because of expected infestations of the Russian aphid. The aphid can be controlled with insecticide but control requires diligent field inspections and considerable cost.

The short growing season in the mountains and the danger of early killing frosts make maize production there more risky than in the foothills and lowlands. Higher acid soils in certain areas, such as in the Nyakosoba prototype area, limit yields of most crops, unless expensive lime is applied to improve the soil pH. The lower rainfall in the lowlands means that the potential yield is lower than in the foothills and mountains. All of these facts must be considered in selecting crops and designing cropping systems for the different ecological zones of Lesotho. Fortunately, high temperatures, low humidity, and excessive winds do not significantly affect the choices available to the researcher and to the Basotho farmer.

As a result of these factors, cropping systems must be designed with maize as the main crop, primarily because it is the preferred crop of essentially all farmers. Therefore, other crops must fit into a system including maize as the basic crop.

A crop rotation is a systematic sequence of growing crops over a number of years on a specific area of land. Very little published information is available on crop rotations in Lesotho, but a knowledge of the crops, the soils, the climate, and crop pests helps point the way to suitable rotations in each area. However, there is a real need for a long term research program on crop rotations.

The choice of crops depends on:

- the expected return from each crop,
- their effects on the following crop and on soil productivity,
- available labor, equipment and other inputs, and
- the experience and desire of the farmer.

The sequence of crops should be chosen on the basis of a number of factors:

- planting and harvesting dates,
- disease problems,
- insect attacks,
- weed problems, and
- their effect on soil erosion control.

An example of a suitable 5-year rotation would be: maize, beans + winter oats, grain sorghum, beans + beans, and winter wheat. In this case the farmer could produce seven crops in 5 years, because year 2 is a double-crop of beans and winter oats for fodder, and year 4 includes two crops of beans. This rotation would be good for either the lowlands or the foothills. If the farmer happened to have five fields of approximately the same size, the same area could be planted to each crop in each year of the 5-year rotation. For the mountains, the winter crops would be left out and spring wheat or spring peas could be worked into the rotation (maize, spring peas, sorghum, beans, and spring wheat). Presumably after the 5-year cropping sequence, the rotation would begin again with maize. If more maize was desired, a second field of maize could be planted in place of one of the other summer crops. These rotations would produce all the benefits associated with crop rotations.

Rotations should be flexible (easily changed) in case the stand fails, crop price change, or there is an unexpected insect or disease problem. The farmer can just as easily have a 3-year or 4-year rotation, by leaving out one or two of the crops or double crops. Potatoes and possibly squash (or pumpkin) can be worked into the rotation in the higher rainfall areas.

The suggested rotations should be tested for 10-15 years, along with any others that might be acceptable. There is a great need for economic studies on rotations, to determine which ones are most likely to produce the most income per hectare. Farmers need some help and guidance in deciding which crops to plant and in which sequence they should be grown. Knowledge of the principles of crop rotations and of the conditions that exist in each area, plus research experience in the different ecological zones of Lesotho, should be relied upon.

e. Soil Fertility Management

Yield responses to fertilizer are very common in Lesotho, especially to N and P. P responses are more frequent and usually greater than from N, especially in certain acid soils that are extremely P-deficient. Response to N application will occur every year on virtually every field in Lesotho, escept where soil P content is extremely low. In such cases, when P is applied response to N is likely. There have been indications of K, Zn, and Mo deficiency, but the extent of these has not been clearly established.

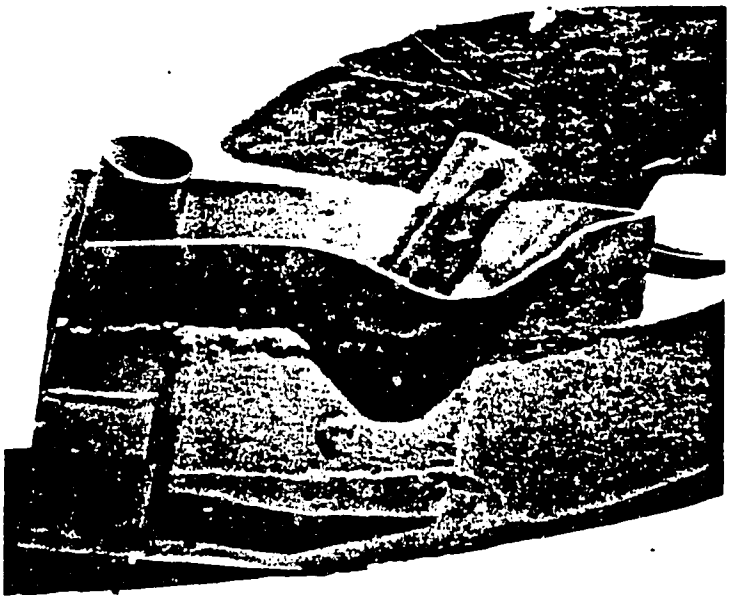
At present, fertilizer recommendations are based on the fertilizer response data available. With a soils laboratory now in operation, there is potential to make recommendations based on soil test results. But this cannot happen until the soil tests are evaluated in soil test correlation research involving fertilizer field trials. Crop responses are then correlated with the soil test values. This is now being done on a limited scale but a much more comprehensive program is needed.

f. Field Plot Techniques

Special Publication. Trower Namane, acting director of the Research Division, MOA, made an important contribution in the application of statistical methods and field plot technique for on-station and on-farm research for developing nations, with his master's thesis, Procedures in Conducting Agronomy Trials, Both On-Station and On-Farm, In Lesotho and Other Countries with Similar Environments. It was written in 1984 at Washington State University, Pullman, Washington, USA.

12. Farm Equipment

An important effort of the Agronomy Section was to adjust and improve farm equipment. Land leveling, seedbed preparation, seeding depth, uniform seeding rate, placement of fertilizer relative to seed, and efficient grain threshing were all addressed (Figs. III-E-2 to III-E-11).



Figures III-E-2 and III-E-3. A modification to the Safim planter was designed and constructed. The modified planter places the fertilizer lower and to the side of the seed.

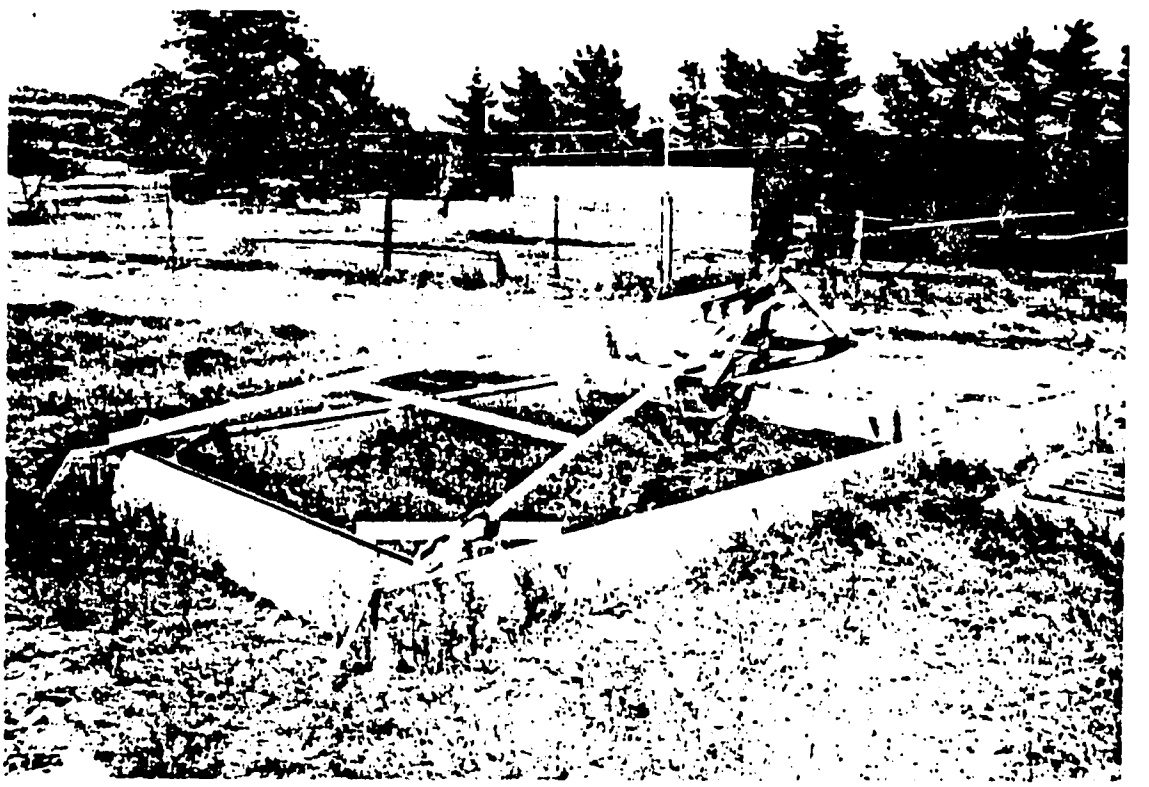


Figure III-E-4. This field leveler was modified by Research Division agronomists. Fields at the Research Station which were leveled using this implement were smoother, more uniformly sloped, water penetrated more uniformly, and seeding depth was more effectively controlled. It was attached to the tractor with a three-point hitch.

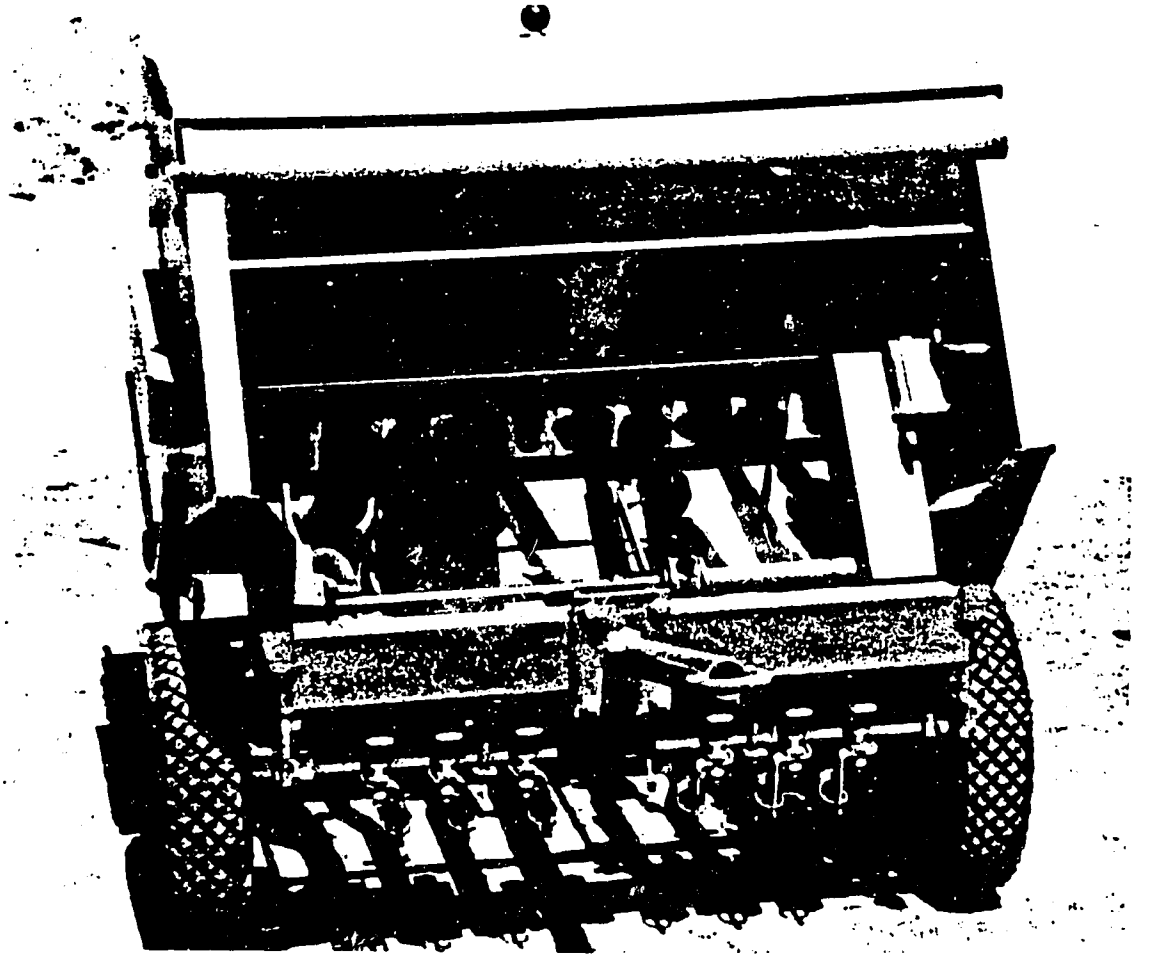
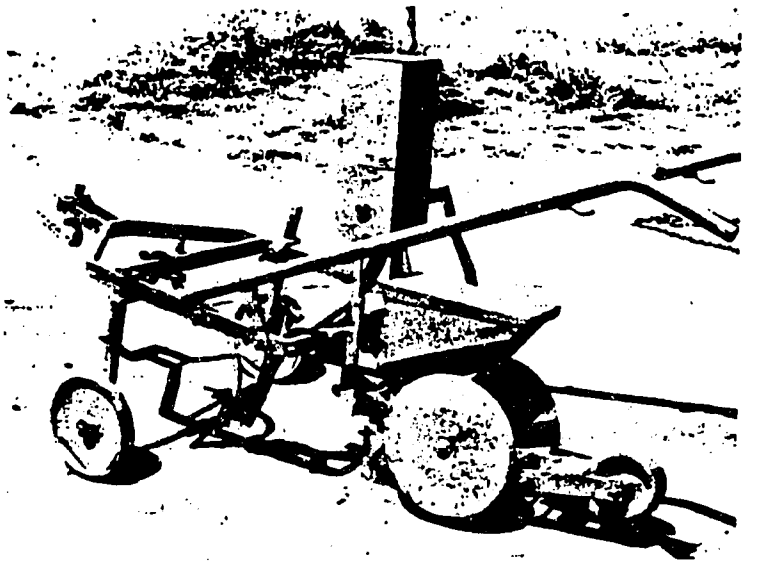


Figure III-E-5. Hassia DM plot seeder, tested by Research Division agronomists. It was easy to calibrate and set seeding rates, and especially useful as an ox-drawn seeder for wheat and other crops that are normally seeded by broadcasting. It is manufactured in West Germany and sold through the Lesotho Cooperative Credit Union League. Farmer cooperative members would find it useful to seed wheat, barley, and fodder crops. The 1986 price was approximately M5500.

Figure III-E-6 and III-E-7. This box level breaks up hard clods and smooths the seedbed, thus enabling more accurate seed placement and a more uniform plant population. Designed, constructed, and tested by Research Division agronomists, it is constructed of wood, and reinforced with steel. It can be pulled by two strong oxen. In tests on small farms, improved seedbeds produced better stands of maize, sorghum, and beans. Farmers can easily construct it using locally available materials for less than M30 (1985 prices).



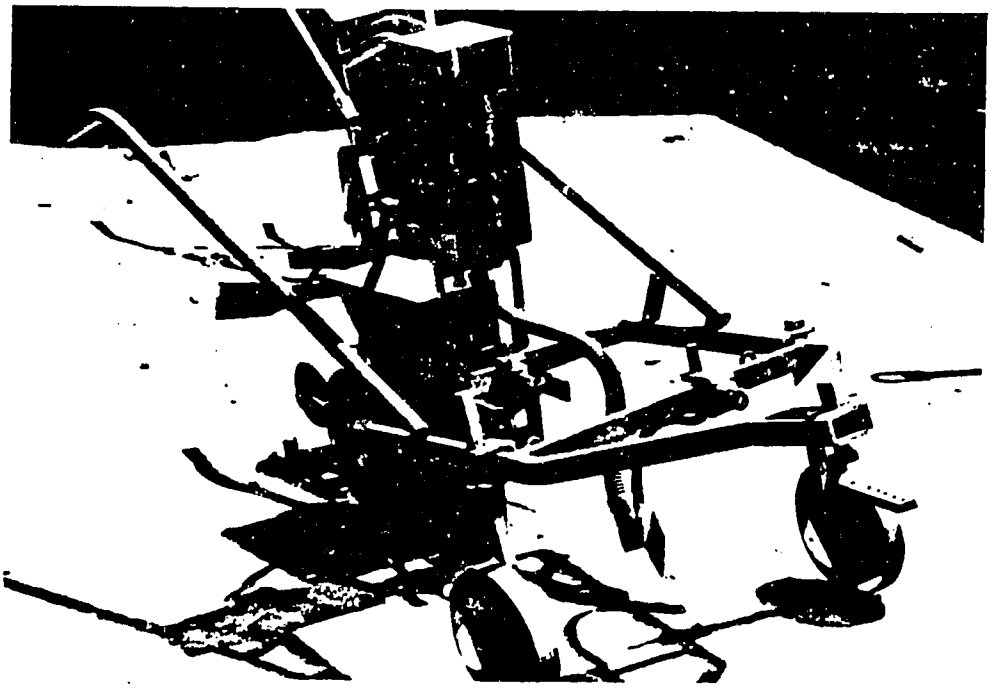


Figure III-E-8 and III-E-9. The Ariana single-row planter worked better than the Safim equipment. The fertilizer shank can be easily adjusted to discharge fertilizer at different distances from the seed. Several seed plates are available for each crop.

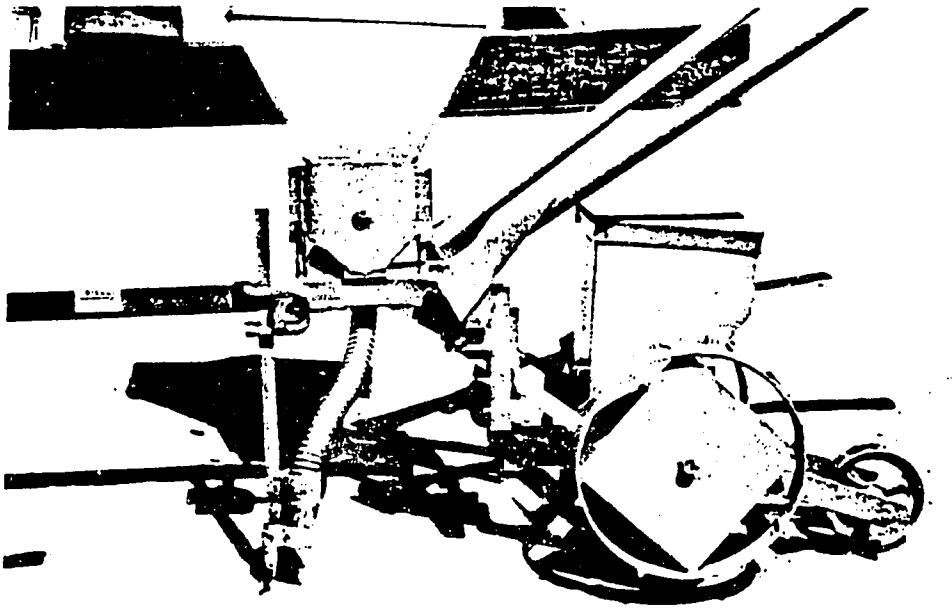


Figure III-E-10. The Matlama planter-fertilizer applicator is modified from the Ariana. Research Division agronomists helped Lesotho Steel Company with the design. The seed-metering unit of the Ariana remains intact, but the balance of the equipment is new. The drive wheels have more traction and are less apt to be stopped by large clods in the field, hence seed is placed more accurately. Price of the entire system was comparable to Ariana, approximately M750 in 1986.

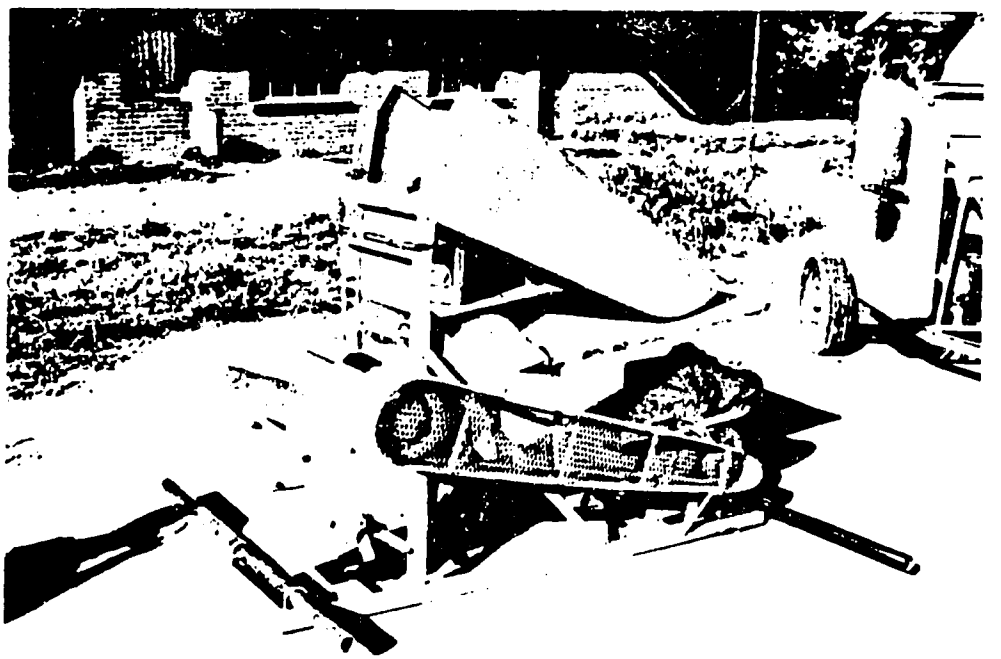


Figure III-E-11. A new thresher that works very well for threshing, but straw and chaff are separated in a second operation. It is simple, inexpensive, and portable.

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The executive summary of this section is on pages 60-67. The summary of accomplishments and recommendations is on pages 96-97.

F. Horticulture

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F. Horticulture

1. Introduction

In 1979 when the FSR Project began, the total hectarage for horticultural crops (4,800 ha) in Lesotho was very small compared to that for field crops (1,105,000 ha) (LASA, 1978). Nearly all the 4,800 ha were in peaches, most of which are grown in backyards. It is of interest that the estimated annual value of peaches was greater than any other crop, including maize or sorghum.

The main vegetable crops are potatoes, cabbage, tomatoes, onions, carrots, pumpkins, and beetroot (garden beets).

The major problems and constraints for vegetable production are essentially the same as those listed for agronomic crops in Section III-E. It is doubtful that the 1978 situation (Table III-F-1) has changed much.

The data clearly show the contribution of these crops to the national income is small, aside from peaches, but the value of vegetables for home consumption is considerable, with a value of nearly R2 million or about 11% of the annual gross income. About 90% of rural families in Lesotho raise garden vegetables.

Table III-F-1. Horticulture production and value data, Lesotho, 1978.

Fruit crops	Trees ('000)	Yield (kg/ha)	Farm price (R/kg)	Gross value (R)
Peaches	1,000	9	.45	R4,050,000
Apricots	60	7	.42	176,400
Apples & others	45	8	.40	144,000
Total	1,105			R4,370,400

Fruit crops	Trees ('000)	Yield (kg/ha)	Farm price (R/kg)	Gross value (R)
Potatoes	90	12,000	.12	129,600
Cabbage	40	10,000	.35	140,000
Asparagus	90	800	.20	14,400
Home gardens	130 plots	------ R15/plot ---		1,950,000
Total	220+			R2,233,000

Source: Various sources as cited in LASA, 1978.

2. Enterprise Budgets

a. Tree fruits

Carvalho (RD-R-29, 1983), who worked in the Nyakosoba prototype area, indicated commercial fruit was successfully grown by one grower. Varieties that performed well were Golden Delicious and Granny Smith apples, and Summerset and Kahamas peaches. Marketing is believed not to be a problem for unblemished fruit. Carvalho provided yield and estimates for supplementally irrigated apples, peaches, pears, and apricots for several years after planting (Table III-F-2).

b. Asparagus

Carvalho (1983) set up an enterprise budget for nonirrigated asparagus in Lesotho. The procedure called for growing 1,425 plants on 0.5 ha assuming a 10-year production time. The work was done in the Nyakosoba prototype area. Yields and returns to land and operator's labor and management over 10 years were estimated:

	Age (years)						
	1	2	3	4	5	--------	10
Yield (m/ha)	0	.75	1.5	2.75	3.25		3.25
Return (Maluti)	-603	297	792	1,617	1,947		1,947

Table III-F-2. Estimated yield and net return to land, and operators land and management per 0.5 ha, selected tree fruits.

	Age of trees (years)							
	1	2	3	4	5	6	7	-- 25
Apples								
Yield (tins)	0	0	0	120	360	720	960	960
Return (R)	-2257	-269	-311	10	694	1765	2522	2522
Peaches								
Yield (tins)	0	0	240	480	720	960		960
Return (R)	-2199	-226	483	1156	1823	2563		2563
Pears								
Yield (tins)	0	0	0	120	360	720	960	960
Return (R)	-2257	-256	-291	38	749	1845	2619	2619
Apricots								
Yield (tins)	0	0	120	240	480	720		720
Return (R)	-2199	-266	57	304	911	1591		1591

Source: After Carvalho, 1983.

The data appear to indicate asparagus is a promising crop for Lesotho. Although the returns are not as high as for tree fruits, there is a positive net return the second year. A pilot scheme described by Majoro and Holland (approx. 1985) for asparagus production involving the Thaba Bosiu Project was initiated in 1974. A cannery was built near Mazenod, and farmers agreed to sell their product to the cannery at a certain price. Repayment of costs by farmers was to be made by a check-off on the rate of output and spread over a 10-year period. Land allocations were 0.1-0.2 ha per grower. By 1976, 22 ha had been planted by 117 growers. Because of the limited asparagus season, there was a need to develop other crops for canning. Dry beans and peaches are two crops that have potential, and are being tested.

c. Vegetables

Borris et al. (RD-B-36, 1985) conducted a study on small-scale irrigated vegetable production, and derived enterprise budgets for 12 crops on 0.1 ha (Table III-F-3).

Borris (1985) collected yield estimates from various sources in Lesotho and South Africa. Yield ranges (t/ha) are:

Cabbage	10-49	Tomatoes	8-50
Onions	8-46	Carrots	6-30
Potatoes	11-27	Beetroot	8-25

Borris (1985), with reference to the economic feasibility of growing vegetables under irrigation, draws the following conclusion:

"The production of vegetable crops on individual, irrigated farms has the potential to be profitable in Lesotho. If profits are

Table III-F-3.

Crop	Yield (t)	Net return to family resources (Maluti)
Beetroot	2.1	223
Early summer cabbage	2.1	12
Late summer cabbage	3.5	49
Early winter cabbage	2.1	33
Late winter cabbage	3.5	102
Carrots	2.0	94
Direct sown onions	2.2	408
Transplanted onions	2.2	468
Potatoes	2.2	198
Pumpkins	1.7	-78
Early tomatoes	1.7	399
Late tomatoes	2.6	691

high enough to keep a large number of producers in the vegetable business, the output from these irrigated operations can move Lesotho closer to its goal of food self-sufficiency. While the potential does exist for vegetable production to be both profitable to the individual and beneficial to society, it should not be regarded as a panacea nor should it be assumed that the introduction of irrigated agriculture will be easy. Presently, many institutional barriers stand between the potential for the development of a large number of small-scale irrigated vegetable farms and the realization of the nation's goals."

In a re-evaluation of the data using different assumptions, Borris concluded that the data did not deserve the optimism originally expressed. In the second evaluation, (Borris et al., RD-B-36, 1985) crops showing a positive return to labor and management were: direct sown onions, transplanted onions, early tomatoes, and late tomatoes. Crops showing negative returns were pumpkin, all cabbage crops, potatoes, carrots, and beetroots.

In short, evaluation of these two graduate studies (Borris, 1985 and Carvalho, 1983) appear to provide more optimism for supplementally irrigated tree fruits than for irrigated vegetables.

3. Vegetable Production

a. Work prior to FSRP

According to Powell et al. (1979) "Acceptable yields of potatoes can be grown in Lesotho." Most of Lesotho's production is in home gardens but they indicated commercial production appears feasible at Leribe, Maseru, Mantanyane, Marakabei, and Thaba Tseka.

They obtained 2-fold to 8-fold responses from fertilizer at five locations, with yield increases ranging from 1,200-1,600 kg/ha. They found that BP-1 and Up-to-Date varieties performed well and that early-planted (late October) outyielded later-planted potatoes. The MOA (1966) reported increases in potato yields from 1,800-14,000 kg/ha from the use of fertilizer. Weinmann (1968) using the Up-to-Date variety reported an increase from 1,875 with no P to 14,000 kg/ha with 50 kg/ha of P. FAO/SIDA (1975) reported similar results. Weinmann (1968) reported, from 3 years' data from trials at Majarmetalane, responses to N, strong responses to P, and little or no response to K on cabbage and green peas. The MOA reported some observational trials on peaches, nursery strawberries, berries (black currants, red currants, raspberries, gooseberries), and vegetables (cabbage, cauliflower, brussel sprouts). No data recorded.

Project work on horticulture crops was somewhat limited until 1984. Very little was done during 1979-81. A limited amount was done on a part-time basis during 1981-83 by Dr. Clark Ballard, who was also party chief of FSRP. There was no horticulture work during 1983-84 Dr. John Downes arrived to work full time during 1984-86. The work on potatoes was done by the Agronomy Section until 1984 when the

Horticulture Section accepted this responsibility. Nearly all work was with vegetable crops, with very little directed at tree fruits or small fruits.

b. FSRP, 1981-82, Summary

K67 Maize - Tomato Intercropping. Tomato yields from the conventional method of staking were 13 t higher (43 vs 30) than those of the intercropped tomato. There was no significance due to row orientation. Intercropping reduced staking costs considerably, so that even though yields are lower, income to the farmer using this method is higher.

K69 Onion Variety x Time of Sowing. Very good yields of onions were obtained from the September sowing. The best varieties were Cream Star, Texas Grano, Hojem, and Bon Accord. Size of onions decreased with later sowings.

K70 Carrots. The early November sowing showed a significant yield difference of the eight varieties at the 1% level. The best yielding varieties were Chantaenay Long, Keystone Danvers, and Cape Market.

K75 Seedling Production Studies Using Cabbage. There was no yield difference due to media or varieties, but Finn Peat seedlings were the quickest to develop and, given adequate growth conditions, earliness could have been an advantage. Yield was 53 t/ha.

Short Day Onions. Four sowings were made from mid-September to mid-December. Quality of three varieties in the first sowing was good: Hojem, Pyramid, and Bon Accord. Size was generally medium to small, and yields were low because of management difficulties such as late thinning and weeding. In the second sowing, the best looking onion was Granex 33. This variety can be seeded directly without thinning to produce a uniform, medium-sized crop. Hojem and Texas Grano also appeared to grow satisfactorily without thinning, but Silver King grows better when thinned. Pyramid was very poor without thinning. Quality was satisfactory from the third and fourth sowings, although yields were low.

Long Day Onions. The onions were sown on 16 Nov 82 using a ball planter, and thinned to 4 cm when they were pencil thickness. They were harvested on 13 May 83. Most varieties grew vigorously and had very large bulbs, but did not reach full maturity and had to be harvested green with the onset of frost. Yields were 30-38 t/ha. The only variety that reached full maturity was Australian Brown, which was attractive, although smaller than the other varities. The yield was 24 t/ha. Order of maturity was: Australian Brown, Caledon Globe and Boller, Sunny and Daapse Wonder, and Kippart and Rockhard. The quality of Caledon Globe and Rockhard was good. Boller was the best looking onion, although green.

c. FSRP, 1984-85

(1) Potatoes

Ripping and Irrigation. Eight treatments were planted at Siloe on a Duplex soil. The treatments were ripping soil to 60 cm (two), irrigation level (three), and in-row spacing (three). In-row spacing was later abandoned as a variable becomes of stand problems. The variety Up-to-Date was planted on 1 Oct 84. There was a severe hail storm on 15 Nov, and irrigation began in mid-Dec. The plots were harvested on 10 and 11 Apr 85, 28 weeks after planting. Total rainfall was 593 mm, and effective rainfall was 370 mm. Effective rainfall is actual rainfall minus 10 mm per occurence (Table III-F-4). Although not shown, there was very little rainfall during the first 7 weeks.

Before discussing the yield data in Table III-F-5, a brief explanation of tuber size categories is in order. The four categories are very small, small, medium, and large. Marketable potatoes are medium and large, but food potatoes also include small. Very small potatoes are, in general, not considered usable. In terms of marketable, food, and total yields, there were highly significant (.01) differences among both irrigation and ripping treatments with some interaction. Best yields were obtained from the medium irrigation treatment with ripping to a depth of 60 cm. The data indicate a relationship between stand, tubers per plant, and grams per plant on the one hand, and the yield level on the other.

Table III-F-4. Summary of water received as rainfall and applied irrigation to potatoes at Siloe in 1984/85 (mm).

Scheduled irrigation level[1]		Weeks 1-11			Weeks 12-28			Season (28 wks)		
		ER[2]	IRR	Sum	ER[2]	IRR	Sum	ER[2]	IRR	Sum
Low	none	143	0	143	226	0	226	370	0	370
Medium	25 mm/wk	143	0	143	226	229	455	370	228	598
High	50 mm/wk	143	0	143	226	419[3]	645	370	419[3]	789

1. By sprinkler to supplement rainfall to ensure scheduled weekly rates of water.

2. ER = effective rainfall = rainfall equal to or greater than 10 mm per occurence (normally per day or 12-hour period unless light showers).

3. Found late in season to be excessive after soil profile filled with rainfall and last three of nine irrigations reduced to supplement rainfall so as to provide 37 mm per week.

Source: Research Division 1984-85 Annual Report.

The data indicate maximum yields of food potatoes of 32 t/ha, with 60 cm of water, of which 23 cm were supplied by irrigation. At this yield level and at water cost of 50 Maulti/cm/ha, evidently potatoes priced at 100 Maluti or more per ton would be profitable.

The effects of ripping on the Duplex soil are of interest because these soils have serious physical as well as chemical problems. Duplex soils have a coarse surface texture down to 30-60 cm, and then change abruptly to a fine-textured soil. Getting the ripping tool into the finer subsoil probably increased permeability and total water-holding capacity. It is encouraging that manipulation of Duplex soils may hold some promises for improvement.

Lime, Kraal Manure, and Fertilizer in an Acid P-Deficient Soil. The trials were planted at Nyakosoba in soil with a pH of 4.6, 2.4 ppm P, 122 ppm K, and 5.4% organic matter. Up-to-Date potatoes were planted 12 Sep 84 with four rates of 2-3-2 (22) + Zn fertilizer placed on each side of the rows at planting. Lime (three rates) and manure (four rates) were broadcast and irrigated. Rainfall was sparse during the first 6 weeks of this nonirrigated trial. Effective rainfall was 583 mm. Plots were harvested at 4 Mar 85. There was a pronounced effect of fertilizer on early plant growth, i.e., higher rates resulted in more large plants (data not shown). Also the second rate of fertilizer resulted in many tubers per plant as compared with no fertilizer (Table III-F-6).

Table III-F-5. Stands and yields of Up-to-Date potatoes in relation to irrigation and deep ripping of a Duplex soil at Siloe, 1984-85.

I+R (cm)[1]	Ripping	Stand ('000/ha)	Tubers/plant Total	Tubers/plant Mkt	Grams/plant Total	Grams/plant Mkt	Yields (t/ha) Mkt	Yields (t/ha) Food	Yields (t/ha) Total
37	0	13.7	14.9	4.2	791	500	6.71	9.08	17.84
37	1	16.9	14.3	4.7	873	570	9.19	12.38	14.29
60	0	20.3	25.3	7.6	1452	950	18.62	24.02	28.36
60	1	23.4	20.8	8.1	1427	1060	24.74	30.31	33.31
79	0	15.0	16.1	5.3	902	627	9.13	11.19	13.20
79	1	20.2	21.5	6.4	1210	767	15.41	20.00	24.10
Average		18.2	18.8	6.1	1109	746	13.97	20.90	20.68
Fi		**[2]	*[3]	*	*	ns	**	**	**
Fr		**	ns	ns	ns	ns	**	**	**
Fir		ns	ns	ns	ns	ns	*	10%	*

1. I+R = season rainfall + irrigation (see Table III-F-4 for details), in cm. Fi = F for irrigation, Fr = F for ripping, Fir = interaction F, all from analysis of variance.

2. ** = Significant at 1% level of probability.

3. * = Significant at 5% level of probability.

There were significant responses to lime and fertilizer, but not to manure. Highest yields were obtained with the highest rate of lime and fertilizer (and manure). It is of interest that lime increased yields while only increasing pH from 4.6 to 4.9. When the cost of seed and fertilizer were subtracted from gross yields, the return to la was low, even at 145 Maluti per ton.

Seed Size, Seed Treatment, In-Row Spacing, and Fertilizer Rate. Two trials of Up-to-Date were planted at Namuha in Mokhotlong District on 24 Oct 84 in a Fusi clay loam. The first trial compared four variables with nine treatments: seed size (two), cut vs whole (two), in-row spacing (two), and fertilizer rate (three). The second trial compared three variables with five treatments: cut vs whole (two), seed treated (with Thiuran) vs untreated (two), and small seed vs large seed tubers. Both trials were harvested on 3 Apr 85.

In the first trial, there was no difference in stand due to seed-size, but whole seed produced approximately 23,000 plants/ha compared to less than 18,000 for cut seed. There was no correlation of fertilizer rate, seed size, or spacing with yield.

Table III-F-6. Lime, manure, and fertilizer treatments and average responses of Up-to-Date potatoes at Nyakosoba, Maseru District, Lesotho, 1984-85.

Lime (t/ha)	Manure (t/ha)	Fert.	N	P	K	Yield (t/ha) Mkt	Total
		(kg/ha)					
0	0	0	0	0	0	0	1.16
0	0	578	36	48	36	9.35	14.87
0	13	578	"	"	"	9.50	15.56
6	0	578	"	"	"	11.30	15.78
6	13	578	"	"	"	12.35	17.49
0	0	1156	72	108	72	15.30	20.91
0	13	1156	"	"	"	9.35	15.38
6	0	1156	"	"	"	15.95	20.33
6	13	1156	"	"	"	15.20	20.18
12	26	1734	108	162	108	19.35	24.22
AVG						11.76	16.59
R^2 (Total)						.468**[1]	.336*[2]
R^2 (Food)						.374**	.407*
R^2 (Market)						.005	.025

1. ** = Significant at 1% level of probability.

2. * = Significant at 5% level of probability.

In the second trial, whole seed tubers produced 31% greater stands and higher yields than cut seed. Small seed tubers were equal to large seed tubers in terms of plant survival. Seed treatment with Thiulin did not consistently improve stands in either cut or whole seed. Total tuber yields were correlated with stands in plots planted with whole seed tubers, but not in those planted with cut seed. No consistent difference between 25 and 50 cm in-row spacing or 0, 800, 1600 kg/ha of 2-3-2 (22) fertilizer levels was found.

Seed Treatment, Spacing, and Fertilizer Rate. Up-to-Date was planted on 23 Oct 84 at Libibing in the Mokhotlong District on a Fusi clay loam on 23 Oct 84. There was a severe hail storm on 19 Dec and frost damage on 24 Dec. There were three treatments with eight variables: seed treatment (with and without), spacing (25 cm and 50 cm in-row), and fertilizer (four). The trial was harvested on 2 Apr 85. There was no response to fertilizer treatment (Tables III-F-7 and III-F-8). Both seeding rate and seed treatment increased yields.

(2) Cabbage

Varieties. Ten varieties were planted at Matsieng in a sandy loam soil on 5 Dec 84, and harvested on 28 Feb and 19 Mar 85. Firmata and Shamrock yielded highest, and Huang Miao was significantly lower in yield and percent marketable heads than others (Table III-F-9).

Figure III-F-1. A potato trial at Nyakosoba.

New Hybrids. Performance of new cabbage hybrids was compared with a standard variety in a trial planted at Maseru on 10 Oct 83 and transplanted on 15 Nov. Eight hybrids plus the standard variety Tokyo Pride were harvested on 8 Mar 84, except Firmata, which was harvested on 1 Feb.

Tokyo Pride, Alta, and Rotan were the highest yielding hybrids in terms of number and weight of marketable heads (Table III-F-10). Tokyo Pride head size was by far the most uniform of all with CV = 3.2% compared to 12-57% (Table III-F-11). Head size uniformity is very important. Based on this trial, Tokyo Pride was outstanding in terms of yield and head size uniformity for spring planting when compared to the new hybrids.

Cabbage Variety and Fertilizer Observations Trials. Six varieties were planted at Nyakosoba for autumn production. Drought during emergence delayed maturity. The trial was sampled early, ahead of full maturity.

Table III-F-7. Seed treatment, in-row spacing, fertilizer treatments, plant stands, and potato yields at Lilibing, Mokhotlong District, 1984/85.

Seed trt[1]	Spacing[2] (cm)	Fert (kg/ha)	Stand ('000 (plants/ha)	No. tubers/plant Total	Food[4]	Mkt	Yield (t/ha) Total	Food	Mkt
0	50	827	12.7	18.5	6.5	2.2	5.89	5.10	2.31
0	50	1654	18.8	15.9	11.4	4.0	9.64	8.62	5.32
0	25	0	25.3	10.8	6.3	2.1	8.05	7.14	4.40
0	25	827	21.5	11.7	7.4	3.7	8.84	8.05	5.90
0	25	827	28.7	18.8	12.7	5.0	18.14	16.21	10.65
0	25	1654	22.9	15.6	9.9	3.2	13.27	11.68	7.18
125	50	0	18.5	11.0	8.3	2.3	9.29	8.16	4.74
125	50	827	17.8	21.4	16.6	7.3	18.03	16.33	11.92
125	50	1654	18.5	15.8	12.9	6.4	33.45	12.70	9.72
125	25	827	35.4	12.6	8.9	5.5	19.84	18.48	12.50
125	25	1654	34.8	18.3	15.0	8.3	34.81	33.11	26.62
125	25	2481	31.2	16.1	12.7	5.6	20.97	19.61	13.89
Average			23.4	15.5	10.7	4.6	16.68	13.76	9.60

1. Seed treatment was grams of Thiulin/30 kg of seed.

2. Spacing is cm between plants in rows planted 73.5 cm apart.

3. Fertilizer = 2-3-2 (22) + Zn.

4. Food yield = marketable and small tubers.

In most cases, fertilization increased the number of medium-sized heads and kg/head. In terms of number and weight of harvested heads in the fertilized plots, N. S. Cross was first and appeared to be the earliest, followed by Hercules, Big Cropper, Green Coronet, and Bonanza. The widely popular Spitzo appeared to be later than the others and may lack growth potential (Table III-F-12). Another trial was conducted on a farm in the village of Ngope-Tsoe (Table III-F-13).

Table III-F-8. Potato stands and yields in relation to seeding rates and seed treatment at Lilibing, 1984/85.

Seed rate (kg/ha)	Seed trt[1]	Stand ('000 plants/ha)	Yield (t/ha) Market	Food	Total
1560	none	13.25	3.81	6.86	7.76
1560	1	18.27	8.79	12.40	20.26
3120	none	24.60	7.03	10.77	12.07
3120	1	33.80	17.67	23.73	25.21

1. Treatment: 1 = 125 g/Thiulin/30 kg seed.

Table III-F-9. Yield, percent marketable, and size of head among 10 cabbage hybrids: Matsieng, 1984/85.

Hybrid	Yield (kg per plot)	Marketable heads (%)	Head size (kg)
Firmata	10.5 a[1]	94 a	1.89 a
Shamrock	10.1 a	100 a	1.69 b
Tokyo Pride	9.4 a	94 a	1.67 b
Fabula	9.1 a	100 a	1.52 b
Riana	8.9 a	83 a	1.57 b
Pacheco	8.9 a	100 a	1.48 c
Ray	8.9 a	94 a	1.57 b
Alta	8.3 a	100 a	1.36 c
Rotan	8.2 a	94 a	1.44 c
Huang Miao	5.8 b	67 b	1.37 c
Average	8.8	92	1.57

1. Varieties followed by the same letter are not significantly different by Duncans New Multiple Range Test.

(3) Onions

Planting Date x Varieties. Six onion varieties were field seeded on three different dates on a Sofonia soil at Maseru. The field was irrigated as needed. Texas Early Grano produced the highest average yield over the three planting dates, followed by Granex 33, which was highest for the second and third planting dates. Pyramid was significantly the lowest yielding variety. At the second planting date, Texas Early Grano and Granex 33 outyielded all others by more than double (Table III-F-14).

Of the onion varieties that form bulbs, bulb initiation is governed by day length, and varieties are therefore classed as short-day, medium-day, or long-day varieties. Onions are usually planted in the spring. Leaf growth predominates until the day length is appropriate to induce bulbing, then leaf growth slows, and energy is diverted to bulb development. Thus the short-day onion varieties are first to bulb and the earliest to mature. The medium-day length varieties follow in time of bulbing and maturity, and the long-day varieties are the latest to bulb and to mature. Most of the short- and medium-day varieties are relatively poor keepers, compared to the

Table III-F-10. Yield and head size of nine cabbage hybrids, 1984/84, Maseru.

Varieties	Marketable heads/plot[1] Number	Weight(kg)	Size	Percent marketable Number	Weight
Tokyo Pride	26.7 a	58.5 a	2.19	92	86
Alta	24.3 ab	55.8 ab	2.26	83	89
Rotan	22.3 ab	47.6 abc	2.14	86	90
Fabula	12.3 bc	45.2 abc	4.13	82	81
Riana	18.7 bc	44.9 abc	2.43	68	78
Pacheco	9.7 c	41.8 bc	4.59	69	69
Ray	11.7 c	40.3 bc	4.17	76	70
Shamrock	12.0 c	37.9 cd	3.25	65	67
Firmata	26.0 a	22.1 d	0.85	76	84
Mean	18.2	43.8	2.89	77	79
Significance	**	**	nsd		
CV%	21.1	13.3	135.7		
Std deviation	3.8	5.8	3.92		
R^2 for vars.	.803	.802	.127		

1. Varieties followed by the same letter are not significantly different by Duncans New Multiple Range Test.

long day varieties, which are the main winter storage onions of commerce. Most of the early and midseason varieties, however, will store for one or two months under favorable conditions. Relationships between number and weight yields to total plant number are shown in Table III-F-15.

The conclusion from the data in Table III-F-15 is that the greater the number of plants, the greater the number and weight of marketable bulbs, or at least high plant numbers do not depress marketable yield. The data do not give a very clear picture of optimum planting date, and further trials appear in order. The consistency of the two varieties, Texas Early Grano and Granex 33, to outperform the others in marketable yield appears to be reasonably well established by these trials. Bon Accord, Hojem, and Silver King occupy an intermediate position in marketable yield, and Pyramid performed poorly.

(4) Tomatoes

Varieties. Fifteen varieties were grown on trellises at Maseru and harvested from February to April (Table III-F-16). The analysis of variance indicated no significant differences in total marketable yield among varieties.

Highest yielding varieties were Willamette, Filax, and Fireball. Earliest varieties were Fireball, Celebrity, and Floradade. Varieties

Table III-F-11. Variation in cabbage hybrid head size, 1984/84, Maseru.

Hybrid	Mean (kg/head)	s[1]	CV%[2]	Range (Mean ±s)[3]
Tokyo Pride	2.19	0.07	3.24	2.12 to 2.26
Rotan	2.14	0.26	12.15	1.88 to 2.40
Riana	2.43	0.30	12.35	2.13 to 2.73
Alta	2.26	0.36	15.93	1.90 to 2.62
Shamrock	3.25	0.82	25.23	2.43 to 4.07
Fabula	4.13	1.66	40.12	2.47 to 5.79
Pacheco	4.59	1.73	37.69	2.86 to 6.32
Ray	4.17	2.36	56.60	3.93 to 6.53
Firmata	0.85	0.11	13.41	0.74 to 0.96

1. s = standard deviation.

2. CV% = Coefficient of variation.

3. Mean ± s includes about 68% of all observations.

Table III-F-12. Comparison of fertilized and unfertilized cabbage at Nyakosoba in autumn, 1985.

Variety	Head size	Unfertilized No.	Unfertilized Kg	Unfertilized Kg/hd	Fertilized[1] No.	Fertilized[1] Kg	Fertilized[1] Kg/hd
N.S. Cross	medium	0	0	0.0	5	20.0	4.0
	small	20	12.0	0.6	15	9.0	0.6
Hercules	medium	0	0	0.0	7	11.2	1.6
	small	20	10.0	0.5	13	11.7	0.9
Big Cropper	medium	0	0	0.0	4	6.8	1.7
	small	20	24.0	1.2	16	16.0	1.0
Green Cornet	medium	0	0	0.0	3	4.5	1.5
	small	20	14.0	0.7	17	13.6	0.8
Bonanza	medium	0	0	0.0	0	0	0.0
	small	20	20.0	1.0	20	20.0	1.0
Average of 5 cvs	medium	0	0	0.0	3.8	8.5	2.2
	small	20	16.0	0.8	16.2	14.1	0.9
	total	20	16.0	0.8	16.2	22.6	1.13
Spitzo	medium	--	--	--	0	0.0	0.0
	small	--	--	--	20	12.0	0.6

1. With 800 kg/ha of 2-3-2(22) + Zn at planting.

Table III-F-13. Comparison of six cabbage cultivars at Ngope-Tsoe in autumn 1985.

	Large heads No.	Large heads Kg	Large heads Kg/hd	Medium heads No.	Medium heads Kg	Medium heads Kg/hd	Small heads No.	Small heads Kg	Small heads Kg/hd
Hercules	6	9.6	1.6	7	7.7	1.1	7	3.5	0.5
Green Coronet	4	6.0	1.5	6	6.0	1.0	10	5.0	0.5
Bonanza	2	3.0	1.5	6	6.6	1.1	12	6.0	0.5
N.S. Cross	6	9.0	1.5	0	0.0	0.0	14	14.0	1.0
Big Cropper	0	0.0	0.0	8	12.0	1.5	12	4.8	0.34
Spitzo	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Average of five cvs	3.6	5.52	1.53	5.4	6.46	1.20	11	6.66	0.60
Percent of total	12	30		27	35		55	36	

Table III-F-14. Marketable yields of medium- and short-day onion varieties at three planting dates in 1984 at Maseru on Sofonia soil.

Variety	Yield (15 kg pockets/ha) Aug 1	Aug 16	Sept 17	Avg.
Texas Early Grano	692 a[1]	1056 a	554 a	767 a
Granex 33	375 bc	1200 a	558 a	711 a
Bon Accord	283 bcd	564 b	383 ab	410 b
Hojem	442 b	533 b	183 b	386 b
Silver King	201 d	306 c	642 a	383 b
Pyramid	234 cd	256 c	154 b	215 c
Average	372	652	412	415

1. Yields followed by the same letter are not considered to be consistently different by Duncans new Multiple Range Test.

Table III-F-15. Percent of onion plants producing bulbs of marketable size at Maseru, 1984/85.

Variety	Planting dates Aug 1	Aug 16	Sep 17	Relative to expected[1] Aug 1	Aug 16	Sep 17
Texas E. Grano	30	33	41	+	+	+
Granex 33	27	39	39	+	+	+
Bon Accord	15	24	58	-	-	+
Silver King	12	19	39	-	-	+
Pyramid	12	26	27	-	-	-
Hojem	23	22	16	+	-	-
Average[2]	20 a[3]	27 ab	37 b			
Expected	19	27	36			

1. Based on Chi Square Goodness of Fit Test within each planting date individually.

2. Analysis of variance indicates these differences are sig. at 5% level of prob. ($F = 4.77^*$, $R^2 = .349$) by LSD test.

3. Yields followed by the same letter are not considered to be consistently different by Duncans New Multiple Range Test.

producing 40% or more were of this yield in midseason were Bonny Best, Supersteak, Champion, Wellamette, Big Girl, and Velox. Most of the varieties had yields of 21 t/ha or more.

Tomato Variety Observation Trials on Seven Farms. Three of a total of five varieties were grown at seven locations in the Nyakosoba area. An early autumn freeze affected production and time of harvest, and drought and hail also affected yields in some cases (Table III-F-17). Velox produced, by far, the highest yields.

(5) Peas

Varieties and Cultural Methods. Four experiments were conducted on a Leribe soil, planted on 16 and 17 Jul 84 and harvested on 18 Dec:

- o A comparison of three pea varieties grown under a double support system (Table III-F-18).
- o Comparison of petit provencial with four other varieties (Table III-F-19).
- o Responses of three varieties to different training systems (Table III-F-20).
- o Comparison of seeding methods (Table III-F-21).

(6) Beans

Tepary and Lima Bean Observations. Red and white tepary beans (*Phaseolus acutifolius*), Henderson bush, and Arizona lima beans (*Phaseolus lunatus*) were planted at Maseru without fertilizer on 31 Dec 84 in an observation plot since there was not enough seed for replication trials. However, more than one plot of each entry was randomly located in the planting, made in the edge of a field planted to pinto beans at a much earlier date. All three types were also planted in small beds at Siloe for observation.

At Maseru the soil was dry at the surface at planting time and it was necessary to scrape away about 4 cm of dry soil in order to get the seeds into adequate moisture for germination. The seedlings emerged quickly, especially the tepary beans, as they will germinate with less soil moisture than the other types. Some 60-day cowpeas (*Vigna unguiculata*) were also planted at the same time in Maseru for comparison.

Among seven 10 m plots of white tepary beans the average yield was 1,176 kg/ha, and the standard deviation was 353 kg/ha, so that two- thirds of the plots had a yield ranging from 823-1,529 kg/ha of air dried mature seeds of good quality. Red teparies in two plots, one 10 m and the other 15 m (70 cm between rows) produced an average 1,084 $\pm$ 170 kg/ha air dried good quality seeds. The 60-day cowpeas in a single 20 m plot produced 734 kg of air dried seed of medium quality or lower due to staining from excessive rain during maturity. The

Henderson bush lima beans produced an average yield of 838 kg/ha of good quality beans plus 868 kg/ha of stained and substandard seed due to rainfall during maturity.

All crops at Maseru were killed prematurely by frosts over the period of 22-25 Apr 85, and the plots were harvested in early May. The plants and pods of the teparies were dry and some pods shattered, but loss was not heavy and the seed was well matured, but there was little seed of marketable quality. The cowpea and lima bean seed pods were still not completely dry and the seed had been stained by rain. The lima bean plants especially tend to be perennial and remain green in the main stem making drying and maturing of the seed difficult unless undercut. The Arizona lima, a vining type, was too late to produce more than a few ripe seeds. It thus appears that further trials with tepary beans may be warrented in Lesotho, preferably with some earlier planting. They are short-day plants, however, and even if planted early will not flower until short days occur. However, elsewhere it has been found that yield is correlated with size of plant and early planting normally produces highest yields.

Table III-F-16. Yields of good fruit of 15 tomato varieties at Maseru 1984/85.

Rank	Variety	Yield (t/ha)	Percent in season		
			Early	Midseason	Late
1	Willamette[1]	41.4	30	46	23
2	Velox	34.8	35	40	25
3	Fireball[1]	32.4	54	23	22
4	Early Girl[1]	27.4	30	37	33
5	Floradade	27.0	48	38	13
6	Big Girl[1]	26.3	42	44	14
7	Piersol VFN	26.0	24	27	38
8	Rossel	24.8	36	39	24
9	Celebrity[1]	24.7	49	31	20
10	Supersteak	24.7	36	50	13
11	Bonny Best[1]	24.5	25	50	24
12	Heinz 1370	24.4	38	32	29
13	Champion[1]	21.8	37	49	14
14	Oxheart	19.9	27	33	39
15	Champion[1]	19.2	29	44	27
Average, 15 entries		26.7	36	40	24
Average, t/ha in season		26.7	9.7	10.6	6.4

1. New varieties.

No yield data were collected at Siloe but observation plots indicated that the teparies were far superior to the lima beans and cowpeas in yield and agronomic characteristics.

4. Educational Programs

Dr. Downes was active in educational programs in horticulture, much of it in cooperation with the Extension Section. He taught astatistics course at Lesotho Agriculture College in 1984-85 with 14 students, and again in 1985-86 with 28 students. He made

Table III-F-17. Tomato variety yields at seven sites in the Nyakosoba area in 1984/85.

	Average yield (kg/plant)					
Sites	Velox	Homestead	Heinz 1370	Peirsol	Floradade	Average
L. Sekese	9.98	4.08	5.56	---	---	6.51
M. Sekese	6.78	2.28	2.88	---	---	3.98
M. Molibeli	2.64	---	---	2.24	2.40	2.43
M. Moerane	1.14	---	---	0.00[1]	0.76	0.95
M. Liphoto	---	---	1.05	0.98	0.38	0.80
R. Manyatsa	---	---	1.24	0.91	0.72	0.96
M. Tsehlo	---	---	0.59	0.58	0.34	0.50
Average	5.14	3.18	2.26	1.18	.0.92	2.38

1. No mature fruit harvested, but green tomatoes harvested and ripened indoors.

Table III-F-18. Yields of three garden pea varieties grown under double support system (twin rows).

Varieties	Yield (g)	Sig.[1]
Cape Freezer	1904	a[2]
Green Feast	949	b
Sugar Snap	831	b
Mean	1188	

1. At 10% level of probability.

2. Yields followed by the same letter are not considered to be consistently different by Duncans New Multiple Range Test.

presentations at all Extension training schools held in 1984-85, speaking mainly on vegetable and potato production practice, post harvest handling, and storage of vegetables. He attended several field days and assisted in training some students, technicians, and field workers.

Table III-F-19. Comparative yields of five garden pea cultivars[1]

Cultivar	Yield (g)	Sig.
Green Feast	736	a[2]
Cape Freezer	624	ab
Sugar Snap	540	ab
Green Feast	736	a
Cape Freezer	624	ab
Sugar Snap	540	ab
Kelvedon Wonder	297	c
Petit Provencal	245	c

1. Of dry seeds.

2. Yields followed by the same letter are not considered to be consistently different by Duncans New Multiple Range Test.

Table III-F-20. Average yields of three garden pea cultivars grown on three different support systems.[1]

	Yield (g)			
Varieties	On net trellis	Double rows	Single rows	Average
Sugar Snap	718	730	677	715 a[2]
Cape Freezer	472	742	491	563 a
Green Feast	260	197	150	216 b
Average	482	628	439	522

1. Dry peas. Same number of rows/plot therefore yields on same basis.

2. Yields followed by the same letter are not considered to be consistently different by Duncans New Multiple Range Test.

Table III-F-21. Dry seed yields of garden peas from four different seeding methods.

Seeding method	Yield (kg)
Precision Planter	1.7
Hand Seeding	1.2
Ball Planter	1.2
Planet Jr.	1.2
Average	1.4

The executive summary of this section is on pages 67-70. The summary of accomplishments and recommendations is on page 97.

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G. Range Management

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G. Range Management

1. Introduction

Lesotho's rangelands are overgrazed. For many years, total livestock numbers have been nearly double the estimated total carrying capacity of the range.

Range vegetation does not recover quickly. Research has shown that, even where there is an early increase in vigor of some species, there is no permanent recovery within one or two years of protection. The recovery rate depends on the condition of the vegetation, soil properties, available seed of desirable species, and rainfall. These factors are presently being evaluated in terms of "leboella", or resting the range. Until livestock numbers have been brought into balance with carrying capacity, there is little point in correcting other factors. It has been demonstrated repeatedly that such practices as range reseeding, brush control, and introduction of new species are not effective on range that remains overgrazed.

This does not imply that range research should not continue. Research is needed to understand social structures that may be used to help resolve the overgrazing problem. Research is also needed to determine what approaches to management of communal range resources are feasible and which ones are not. It is hoped that animal numbers will be brought into balance with carrying capacity by thoughtful planning supported by research results, rather than by nature through catastrophic events such as droughts.

Then, when livestock numbers are in balance with the land, FSR's reclamation and reseeding recommendations will be useful to increase forage quality and land conservation. Recommendations for correct species, rate, and time of seeding are available. When seedings are established, livestock numbers may again be increased if numbers are controlled at the recommended stocking rate.

The nature of range management research requires that the research projects be long-term. Data from short-term research--two or three years--are often inconclusive, even when differences are statistically significant.

A serious problem in Lesotho's ranglands is invasion by shrubs such as sahalahala (*Chrysocoma tenuifolia*). Neither 2,4-D or 2,4,5-T are effective in controlling this shrub. Other silvicides such as Tordon and Roundup are effective but expensive. Burning, although low cost and effective for control, may lead to erosion. Hand pulling is also effective but reinvasion may occur if overgrazing continues.

Data are available on the nutritive analysis of forage at various times during the year. Crude protein of grasses is as low as 3% in winter, and some forage species are as low as 1.5%. Crude protein requirement in winter is approximately 6% for pregnant cows and nearly 8% for pregnant ewes. Nutritive values of forbes and shrubs for Lesotho are still not known.

Feeding supplemental protein has not solved the deficiency problem, probably because the animals lack energy in the winter. The animals use the protein supplement to meet their first energy requirement. High energy by-products such as hominy chop, winter fodder, or pasture reserves must be considered. Range and livestock extension efforts must be increased to convey this information to the livestock operations.

FSRP Range Management research programs were conducted under the leadership of James A. Tiedeman in 1979-83, and Carl. J. Goebel in 1983-86. Others who made significant contributions are listed in Section III-A (Administration).

2. Bibliography of Range-Related Research

In 1981, Tiedeman assembled an annotated bibliography of range and range-related research (Tiedeman, 1981, RD-R-7). This report covers work done by various development projects and MOA divisions, and discusses the relationship between previous work and the Farming Systems Research Project. He concluded that the most important need is for long-term range research (15 years).

3. Range Condition and Range Resting

Wieland's master's thesis (1984) is a good introduction to range conditions in Lesotho.

a. Range Condition and Trend Monitoring in Molumong

Forty permanently-marked transects were sampled for species frequency and basal cover in 1981 and 1982 (Tiedeman, 1983, RD-R-34). Readings were significantly different from one year to the next, but differences were small and the degree of utilization affected parameter readings. These results demonstrate that the trend in range condition in Molumong can be monitored from these transects, but should be compared over long periods (5-10 years). Although not significant, it appears that the total vegetation basal cover is decreasing in the Molumong prototype area (Table III-G-1).

b. Rested Range Exclosures

Eight 10 m x 15 m exclosures were established in the Molumong area during the summer of 1981 (Tiedeman, 1983, RD-R-34). During the autumn of 1982 two cages were placed outside the fence on the previously grazed area. The following autumn, vegetative cover, species vigor, and forage production were measured. Species vigor was 50% greater and highly significant from the rested range as compared to the grazed range (Table III-G-2). However, resting did not increase forage production (Table III-G-3). No significant differences were detected between rested and grazed treatments for bare soil cover or total vegetation basal cover, but there was 5% more

litter on the rested range (p = 0.05) than on grazed range (Table III-G-4).

These data show the vigor of the dominant grass species improves after one year's rest, but forage production and vegetation basal cover require more than one year's rest to improve. Contrary to popular belief in Lesotho, range condition cannot be improved rapidly with one year's rest nor does forage production increase substantially. Lesotho's rangelands require many years of either rest or deferred grazing at proper stocking rates before substantial improvements can be expected.

The results of this research plus the results of four other exclosures in the Nyakasoba area have been published (Tiedeman, 1983, RD-R-34). This additional research found that total vegetation basal cover actually decreased slightly with rest. It was concluded that light grazing pressure would provide better protection of the soil

Table III-G-1. Basal area and species frequency data compared between years 1981 and 1982 for three plant associations, Molumong.

Parameter	Festuca/ Merxmuellera 1981	Festuca/ Merxmuellera 1982	Themeda/ Harpochloa 1981	Themeda/ Harpochloa 1982	Cymbopogon/ Eragrostis 1981	Cymbopogon/ Eragrostis 1982	Mean 1981	Mean 1982
Soil basal area	25.6	25.4	33.4	31.9	53.0	42.5**[2]	39.1	34.3**
Litter basal area	24.8	28.7	14.1	25.5**	12.0	24.7**	16.2	26.0**
Vegetation basal area	47.3	45.0	47.6	39.9	25.7	27.0	38.3	36.2
Dominant grass basal area	8.1	7.7	21.9	16.5	6.8	7.9	12.2	10.7
Dominant grass frequency	27.8	30.0	61.8	63.0	28.0	33.6*	39.2	42.5*
Codominant grass basal area	8.2	6.8	10.1	7.2	6.4	7.3	8.1	7.2
Codominant grass frequency	32.3	37.8	35.3	36.5	30.0	34.8	32.4	36.2
No. of stands	9		11		13		33	

1. Basal area of rock was measured but is not summarized in this table. Dominant is Festuca, Themeda, or Cymbopogon species, but codominant is any grass species measured as the second most abundant in the stand.
2. Means followed by * or ** are significantly different at p = 0.05 and 0.01 respectively.

Source: Tiedeman, 1983, RD-R-34.

from erosion than no grazing, and most certainly better protection than heavy grazing. Proper stocking rates and deferred grazing rotations would be a better alternative for range improvement than complete rest followed by heavy stocking once the area is reopened to grazing in the communal system.

4. Stocking Rate

a. Proper Stocking and Special Use Areas

An 88 ha grazing area was set aside and stocked lightly with milk cows, one each from 22 cooperating farmers from the village of Ha Lebamang (Tiedeman, 1983, RD-R-34). The range was estimated to be in fair condition with an estimated carrying capacity of 3.5 animal unit months per hectare during years of normal precipitation. An exclosure was established in the area in 1981 and harvested annually. Annual dry matter standing crops for 1981, 1982, and 1983 were 1,327, 2,074 and 1,658 kg/ha respectively. The farmers elected a management committee and hired a herdboy.

Table III-G-2. Average species vigor as measured by leaf length (cm) of rested compared to grazed range and of clipped compared to grazed range in 1983.

Species	Paired plot Rest	Paired plot Graze[1]	Paired plot Clipped	Paired plot Graze	Number of plots
Themada triandra	12.4	8.5**[2]	9.2	9.1	10
Festuca caprina	20.9	11.8	16.0	15.3	5
Merxmuellera disticha	12.0	8.0	10.8	10.8	5
Harpochloa falx	6.4	5.3*	7.0	6.8	3
Eragrostis raemosa	5.7	4.7	4.5	3.6	4
Andropogon appendiculatus	16.7	7.0	10.2	7.6	2
Cymopogon plurinodis	15.5	12.5	13.9	14.1	2
Hyparrhenia hirta	11.5	7.1	9.7	8.0	2
Eragrostis capensis	6.5	5.1	-	-	2
Grand mean	12.0	7.8**	10.2	9.4	

1. Grazed plots were protected from grazing during the growing season prior to leaf measurement.

2. Differences between means are significant (*) at the 5% level or highly significant (**) at the 1% level using the paired t test.

Source: Tiedeman, 1983, RD-R-34.

b. Proper Stocking at Matseng and Mangaung Cattle Posts

Following a suggestion, the possibility of a grazing association for the people who were using the Matseng winter grazing area in the Molumong prototype areas was investigated (Tiedeman, 1983, RD-R-34). The 10-15 farmers then using the area would be given priority for membership. Once the association was formed, only members would be permitted to grazed the Matseng winter post and a selected summer post.

The boundaries of two areas were mapped. The Matseng area includes 1,200 ha of range in fair to poor conditions with an estimated carrying capacity of 300 animal units (AU) over the 6-month winter season. The Mangaung area (summer area) had 3,400 ha in fair condition with an estimated carrying capacity of 700 AU over the 6-month summer season. Range burning trials in the area indicated burning would increase the carrying capacity. In 1982 the Chief agreed to stop issuing permits for Mangaung when the 700 AU were reached. Traditionally, permits had not been issued for the Matseng area. A serious constraint was that only two farmers had applied for permits, but many people used Mangaung the previous year. That method of enforcement was inadequate. The grazing control supervisors planned for the first time to check permits. The success of the permit system was to be observed by grazing control supervisors at Mangaung.

Table III-G-3. Annual standing crop forage yield (kg/ha) measured 1 year after the treatment of range rested 1 year and range continuously grazed in Molumong.

Vegetation type	Exclosure number	Rested range	Grazed range
Themeda/Harpochloa	1	686	663
Festuca/Merxmuellera	2	866	689
Themeda/Marpochloa	3	749	896
Festuca/Merxmuellera	4	342	286
Themeda/Harpochloa	5	338	410
Cympopogon/Eragrostis	6	446	433
Cymbopogon/Eragrostis	7	697	915
Festuca/Merxmuellera	16	885	896
Mean[1]		626	649

1. Means are not significantly different (P = 0.05) using the paired t-test.

Source: Tiedeman, 1983, RD-R-34.

A different summer grazing area could be identified for exclusive use by Association members, hopefully near the winter area.

c. Proper Stocking and Supplemental Feeding of Sheep and Goats

Nine farmers participated, each contributing 20 ewes and 20 angora does for the trial. The treatments were light-stocking and heavy stocking on communal range, each with and without protein-mineral supplemental feeding (Research Division, 1983, RD-R-19). Average wool yield and quality per sheep, ewe liveweight and lamb crop were highest for the lightly-stocked/supplement, followed by lightly-stocked/no supplement and lowest for the heavily-stocked, communally grazed/no supplement (RD-B-19, Table 3). Angora goats were added to the trial and supplement was provided for half of the farmers for the heavily stocked communal grazing/supplement for the second year of the study. Early results from the first mohair clip in May were inconclusive. Average fleece weight for the goats across all treatments was only 1 kg per doe.

5. Range Burning

The impact of uncontrolled range burning during winter was evaluated for three sites in Nyakasoba 3 years after the burn (Tiedeman, 1983, RD-B-34). Forage production and grass species vigor

Table III-G-4. Percent basal cover of rested range compared to grazed range in Molumong, 1983.

Vegetation type	Exclosure number	Bare soil		Litter		Total vegetation	
		Rest	Graze	Rest	Graze	Rest	Graze
Themeda/Harpochloa	1	36.5	34.6	34.2	34.2	29.1	31.2
Festuca/Merxmuellera	2	22.4	24.4	34.2	23.8	43.4	51.8
Themeda/Harpochloa	3	32.4	28.4	35.6	28.2	30.8	42.2
Festuca/Merxmuellera	4	5.7	6.9	31.4	29.8	62.3	63.1
Themeda/Harpochloa	5	18.2	18.0	32.2	35.8	49.6	45.0
Cymbopogon/Eragrostis	6	50.2	55.6	18.8	14.5	22.4	21.5
Cymbopogon/Eragrostis	7	34.8	41.2	29.0	14.5	29.4	44.3
Festuca/Mermuellerra	16	42.5	45.2	27.4	22.4	30.1	31.4
Mean		30.3	31.8	30.4	25.4	37.1	41.3
t		1.17		2.41[1]		1.77	

1. Means are significnatly different at (0.05).

Source: Tiedeman, 1983, RD-R-34.

were measured on the four treatments of burned or not burned and grazed or not grazed. No differences were detected for species vigor between burned and not burned, but vigor was much lower (significant at P = 0.05) on grazed range (7 cm leaf length) than on not grazed range (17 cm leaf length) (Table III-G-5). Over a 3-year period, forage production was reduced by 25% from burning (significant at P = 0.05) for the drought year of 1983.

Prescribed burning was applied to Merxmuellera vegetation at Sani Top after the first spring rains. The vegetation was unpalatable to livestock in its mature growth condition. After burning the vegetation becomes palatable. With management after burning the carrying capacity of this major vegetation type could be doubled.

6. Rotational Grazing/Seasonal Harvest

a. Short Duration Rotational Grazing System Trial

A nine-pasture rotational grazing system was successfully established without fence for the entire grazing area of the village

Table III-G-5. Plant species vigor by leaf length in cm and (standard deviation) for burned and not burned treatments at three exclosures in Nyakosoba 3 years after burning and exclosure establishment.

Plant species and exclosure name	Inside exclosure		Outside exclosure but inside cage	
	Burn[1]	Not burn	Burn	Not burn
Majelefa's burn				
Hyparrhenia hurta	10.6(2.0)	12.3(2.2)	6.7(1.1)	7.5(2.3)
Gabirel's burn				
Eragrostis racemosa	4.8(1.2)	6.0(0.8)	3.9(1.0)	4.5(1.1)
Eragrostis capensis	6.7(1.8)	6.3(1.8)	5.1(1.0)	5.0(1.1)
Themeda triandra	13.6(2.8)	11.3(1.6)	10.8(1.5)	10.0(2.6)
Rock rabbit burn				
Andropogon appendiculatus	17.1(2.2)	16.2(2.7)	7.0(1.4)	--[3]
Themeda triandra	16.0(3.8)	19.0(3.2)	9.8(1.8)	9.9(1.6)
Mean	11.46a[2]	11.85a	7.21b	7.38b

1. Differences between treatments and between species were highly significant (P = 0.01).

2. Means followed by a different letter are significantly different (P = 0.05) using a least significant difference of 2.71.

3. 7.0 cm was used for the missing value.

Source: Tiedeman, 1983, RD-B-34.

of Ha Mokela in the Nyakasoba prototype area. Pastures were consistently rotated with each grazed for 1 week followed by 8 weeks of deferment (Tiedeman, 1983, RD-R-34). After three years, this trial demonstrated that farmers are willing and able to cooperatively rotate pastures. The proper stocking rate has not yet been achieved but the stocking rate was reduced after farmers sent their livestock to the summer cattle post earlier than previous years.

The estimated proper stocking rate for the area is 37 AU throughout the year. The village owns 189 AU. There is only enough forage on the village rangeland to support all these animals for 2.5 months. The actual stocking rate was monitored throughout the study by counting the livestock in the area at different times of the year, and by a village interview at the beginning of the trial (Table III-G-6).

The actual stocking rate was lower than the number of animals reported to be owned by the village in interviews but considerably greater than the recommended rate. The productivity of the range will not improve until the stocking rate is reduced. One approach might be to keep all small stock at cattle posts all year. The problem of overgrazing at the cattle post would still be unresolved but village range would be properly managed. Rotational grazing does little good if the range is overstocked.

b. Seasonal Harvest of Standing Crop Vegetation From Various Vegetation Types in Lesotho

The effect of seasonal harvesting on plant vigor, vegetative cover, reproductive culm density, and total standing crop biomass was evaluated on four mountain sites in Lesotho (Tiedeman, 1983, RD-B-34). *Themeda triandra* was the dominant or codominant species at three sites and *Hyparrhenia hirta* the dominant species at the fourth site. Most plots were harvested once annually for a particular month and

Table III-G-6. Livestock counts, 1981, Ha Mokela.

Date	Camp no.	Small stock	Cattle	Horses	AU
6 Nov 81	4	80	49	29	94
8 Dec 81	9	246	74	0	123
8 Dec 81	1	97	33	7	59
21 Dec 81	3	146	52	0	81
18 Feb 81	5	268	53	11	122
27 May 82	3	239	41	10	99
May 1981 interview		302	90	44	189

Source: Tiedeman, 1983, RD-R-34.

reharvested during the same month over a period of 4 years to simulate seasonal grazing. All plots were evaluated in the autumn of the fifth and sixth year.

The vigor of Themeda triandra, as estimated by leaf length, was significantly greater on the spring-harvested and control plots than on the summer-harvested plots. The vigor of Hyparrhenia hirta was greater on plots that received 1 year's rest after autumn harvest than plots harvested annually in the spring. It appears that early spring grazing with summer deferment is less detrimental to Themeda triandra than summer grazing.

A second objective of this study was to monitor the annual dry matter standing crop yield at various sites and precipitation zones in Lesotho. Annual yields and the average yield over 8 years for each site was determined (Table III-G-7).

7. Nitrogen Fertilization

a. N Fertilizer Rates and Harvest Frequency Response from Two Varieties of Erogrostis curvula.

The response to N of two varieties of Erogrostis curvula, Ermelo and American Leafy, was studied during 1974/76-1979/80 at Matelile, in the Mafeteng District (Ramakhula et al., RD-R-6). A nurse crop of E. teff at 15 kg/ha was sown with the E. curvula at 5 kg/ha. The N fertilizer was applied at 5 rates, 0-90.5 kg/ha, and harvested at 3, 8, 10, and 12 weeks. First year data were:

N (kg/ha)	Ermelo (kg/ha)	American Leafy (kg/ha)
0	4380	6717
22.5	5952	5490
45	8122	8476
67.5	7491	7641
90.5	7557	7811
Mean	6700	7227

The data (Table III-G-8), indicate:

- In every case, there was a response to N, i.e., for each of the 5 years, for both varieties, and for all three harvest intervals. In some cases yields were doubled with N.
- There was a strong trend toward higher yields with longer harvest interval. Yields for the 12-week interval were markedly higher than for the other two.
- Except for the second year when yields of Ermelo were very high, it is doubtful that yields between varieties were significantly different.

Table III-G-7. Annual dry matter standing crop yield from six exclosure sites in Lesotho over 8 years.

Site and precipitation zone	Harvest date[1]	Annual dry matter standing crop (kg/ha)	Dry matter yield av. 8 yrs. (kg/ha)	Dominant species and range condition
Likaleng	1985	1045		
	1983	1148		
	1982	757		Themeda triandra
	1981	2295		
	1980	2682		
	1979	1167	1510	Good condition
	1978	1394		
	1977	1226		
	1976	1511		
Lekubane (800-1000 mm)	1983	1700		
	1982	1476		Themeda triandra
	1981	1925[2]	1856	
	1980	3294		
	1979	1006		Good condition
	1978	1685		
	1977	2296		
	1976	1464		
Thaba Bosiu (800-1000 mm)	1983	553		
	1982	1009		Hyparrhenia hirta
	1981	4138		
	1980	1728	1680	
	1979	1215		Fair to good condition
	1978	596		
	1977	1800		
	1976	2400		
Mokhotlong (400-600 mm)	1985	743		
	1983	950		
	1982	388		
	1981	587		Aristida/ Themeda
	1980	709	639	
	1979	574		
	1978	729		Poor condition
	1977	639		
	1976	535		
Oxbow (1000+ mm)	1979	481		Festuca caprina[3]
	1978	610	466	
	1977	354		
	1976	419		Fair condition

Table III-G-7. Cont'd.

Site and precipitation zone	Harvest date[1]	Annual dry matter standing crop (kg/ha)	Dry matter yield av. 8 yrs. (kg/ha)	Dominant species and range condition
Matelile (600-800 mm)	1982	859		Eragrostis curvula Planted in 1976, no fertilizer applied
	1980	1220	1488	
	1979	1650		
	1978	1893		
	1977	1819		

1. These harvest yields are based on the average of three or four samples during the autumn of each year.

2. Fresh weight was 3,500 kg/ha, dry weight estimated to be 55%.

3. This is a bottomland moist site, not typical of most Festuca caprina vegetation in Lesotho.

Source: Tiedeman, 1983, RD-B-34.

8. Brush Control

a. Brush Control

An area of rangeland in the Molumong prototype area infested with Chrysocoma tenuifolia was fenced in February 1981. A randomized split-plot design was used with or without Eragrostis curvula seeding as the main treatments, and hand pulling, spraying with 2,4,5-T, resting, and burning as the subplot treatments (Tiedeman and Manoto, 1983, RD-B-21). The grazed area outside the fence was used as the control. The density of live shrubs, vegetative cover, species vigor, and forage production were measured in the autumn of 1983 (Table III-G-9).

Hand pulling and burning were most effective in reducing shrub density in comparison to the grazed control. Forage production was lower on the burn and pull, spray or rest treatments. The vigor of both Themeda triandra and Festuca caprina was lowest for the grazed-control treatment and highest for the rest and spray treatments (data not shown).

Table III-G-8. Dry matter yields (kg/ha) of two varieties of *E. Curvula* at five N rates and three harvest frequencies.

N rate (kg/ha)	Harvest interval, (weeks)							
	Ermelo				American Leafy			
	8	10	12	Mean	8	10	12	Mean
			Second year, 1976-77					
0	1601	2939	2472	2335	1926	1016	965	1302
22.5	2574	5299	3718	3863	1241	1512	1692	1481
45	3930	6220	5614	5255	2110	2756	2952	2606
67.5	5329	2655	6061	6348	2862	3810	4276	3649
90.5	4234	9900	7221	7118	2668	3854	5590	4037
Mean	3534	6401	5017	4984	2161	2590	3095	2615
			Third year, 1977-78					
0	1502	-	2182	1842	1689	-	2279	1944
22.5	2112	1694	2456	2087	1785	1789	1973	1849
45	2806	1500	2794	2366	2183	1769	2604	2185
67.5	2994	2006	3192	2730	2279	1956	3185	2448
90.5	3702	1981	3311	2998	2970	2515	3059	2848
Mean	2623	1795	2787	2401	2101	2007	2620	2264
			Fourth year, 1978-79					
0	609	760	3069	1479	590	-	3224	1907
22.5	934	977	3702	1871	881	-	3797	2339
45	1069	1118	3422	1870	932	-	4187	2560
67.5	1103	1695	4701	2500	1094	-	5429	3264
90.5	1298	1656	5843	2932	1297	-	6029	3664
Mean	1003	1241	4147	2130	959	-	4533	2746
			Fifth year, 1979-80					
0	1097	1036	1608	1247	938	976	1660	1191
22.5	1212	1324	2506	1680	1003	1100	1908	1337
45	1414	1597	2521	1844	1372	2034	3713	2373
67.5	1716	1397	2421	1861	1953	1642	2159	1918
90.5	2098	1741	2382	2074	1524	2128	3054	2235
Mean	1507	1419	2298	1741	1358	1576	2499	1811

Source: Ramakhula et al., RD-R-6.

b. Chrysocoma Tenuifolia Reinvasion On Control Plots In Northeastern Lesotho

Chrysocoma tenuifolia (sehalahala), a continuous threat on rangelands, has been increasing during the past decade under persistent heavy grazing, which decreases competition from perennial grasses. The shrub decreases the quality of desirable forage and can poison livestock. Control with chemicals is possible, as is burning at certain seasons. When shrublets are exposed to fire the plant has little power of regeneration. Pulling and chopping the plants are effective but labor intensive. Years of complete protection with no grazing are required before C. tenuifolia is naturally replaced. The reinvasion of shrublets is a factor that must be considered in determining a recommended control method (Goebel et al., 1986, RD-B-42).

The study was carried out at Matseng grazing area in the Bobatsi drainage about 20 km southwest of Mokhotlong on a 15% northeast facing slope at 2900 m elevation. These soils are Mollisols. The mean annual rainfall is 800 mm. C. tenuifolia densities in the study area were estimated at 28,400 plants/ha at the start of the field trials.

Treatments were initiated in 1981 (Tiedeman and Manato, 1983, RD-B-21). There were four treatments: pulling, spraying 2,4,5-T with 4.5 kg/ha active ingredient, rest, and burning. Superimposed randomly upon half of each treatment was a broadcast seeding of Eragrostis curvula cv. Ermelo at a rate of 5 kg/ha live seed. All treatments, except burning, were applied on the 5 Dec 1981. Burning was done on the 9 Nov 1982 at which time 2,4,5-T was applied for the second time at a rate of 4.5 kg/ha of active ingredient (Table III-G-9).

Table III-G-9. Average density (x 100) per hectare of Chrysocoma tenuifolia shrubs 1 year after brush control treatments.

Treatment	Shrub density	
	Live	Dead
Pull	14 a	0 a
Burn	85 b	220 c
Rest	202 c	65 b
Spray	227 c	100 b
Graze	296 d	17 a

Note: No significant response from seeding was detected.

Source: Tiedeman and Manoto, 1983, RD-B-21.

First measurements were made in April 1983. Follow-up measurements were made in April 1985, duplicating the initial measurements whenever possible. However, during 1985 C. tenuifolia live shrublets were counted in addition to density and canopy cover of live mature plants. Canopy cover of dead plants was not estimated in 1985 because of the indefinite crown periphery of these plants.

Pulling resulted in the lowest density and canopy cover of C. tenuifolia (Table III-G-10). Burning was second most effective. Spraying with 2,4,5-T was significantly more effective than initially determined. In 1983 an average density of 227 plants per 10 m^2 plot and a canopy cover of 20% were measured in spray plots, but by 1985 the average density was 137 plants and canopy cover decreased to 16%. These differences were significant at the .05 level. Probably only one-third of the 2,4,5-T decrease was due to protection from grazing. Pull treatments significantly increased density from 14 to 27 plants per plot from 1983 to 1985. However, over 80% of this increase was in the form of shrublets. No other treatment displayed such a change in shrublet density. Density within the rested plots indicated a continuous decline over time in numbers and canopy cover of C. tenuifolia from 202 to 174 plants per plot and 28 to 17% during the 2-year period. These differences, however, were not significant. On the other hand, as measured in 1985, differences between rested and grazed plots were highly significant, averaging 308 live plants in grazed plots outside the exclosure vs 174 inside the rested plots.

Table III-G-10. Average density per 10 m^2 plot (x100 = hectare) and percent canopy cover of Chrysocoma tenuifolia mature plants after 1981 shrub control as measured in 1983.

Treatment	Shrub density			Canopy cover			
	Live			Dead		Live	
	'83	'85	'85[1]	'83	'85	'83	'85
Pull	14a	27a	88a	0a	4a	0a	3a
Burn	85b	49a	16b	220c	146c	4a	4a
Rest	202c	174b	2b	65b	66b	28c	17b
Spray	227c	137b	5b	100b	54b	20b	16b
Graze (control)	296d	308c	6c	17a	48b	33c	31c

1. Percent shrublet density.

Source: Goebel et al., 1986, RD-B-42.

The density of C. tenuifolia in 1983 in the grazed sites averaged 296 per plot. The rested plots thus indicated a significant decrease in C. tenuifolia of 7% density per year. The overall reduction to 174 plants per plot from the rest treatment as measured in 1985, indicates a total decrease of 40%. Likewise, canopy cover decreased 42% during the same period. Thus, it appears that with rest from heavy grazing, it would take approximately 10 years for C. tenuifolia to be theoretically eliminated.

Consistently, longer leaf lengths were found in F. caprina and the shortest is H. falx as in 1983 (Table III-G-11). Spray and rest treatments resulted in the longest average leaf lengths in 1983 and 1985. The rest treatment averaged the longest leaf lengths for T. triandra in both years (Table III-G-12).

It appears that natural successional replacement of C. tenuifolia by native grasses on this site will take considerably longer than originally predicted. A resting time of 10 years is not practical, especially since resting the range did not significantly increase yields as compared to other treatments. On the other hand, such expensive, complete control treatments as pulling appear to gradually result in problems of reinvasion of shrublets. However, pulling with repeated efforts to reseed the sites with native or introduced grasses appears worthy of continued investigation. Control of C. tenuifolia is not recommended unless the number of stock animals is reduced to carrying capacity. Burning is effective only if grasses are present as the understory fuel. In the future it may be desirable to test light and moderate grazing intensities as compared to complete rest. It may be that forage production could be stimulated by some grazing in contrast to the complete protection from all grazing.

Table III-G-11. Leaf length (cm) of three dominant grass species resulting from different shrub control treatments.

Treatment	Themeda triandra		Festuca caprina		Harpechloa falx	
	'83	'85	'83	'85	'83	'85
Pull	11.1b	8.3b	27.2b	23.5c	7.1b	6.7b
Burn	11.1b	9.2b	28.1b	24.2c	8.7c	7.3c
Rest	14.7c	12.1c	30.0c	21.0b	9.2c	7.5c
Spray	13.9c	8.9b	31.7c	21.1b	9.4c	7.3c
Graze (control)	8.2a	6.2a	23.4a	14.1a	5.0a	3.9a
Mean[1]	11.7	8.9	28.1	20.8	7.9	6.5

1. Means with the same letters are not significantly different at the 5% level.

Source: Goebel et al., 1986, RD-B-42.

c. Leucosidea sericea Copice-Regeneration Responses When Controlled in Southern Lesotho

"Che che" (Leucosidea sericea) is the second most important native brush "pest" in Lesotho. It is a much taller and persistent bush than sehalahala (Chrysocoma tenuifolia). L. sericea is more restricted in its distribution than C. tenuifolia in Lesotho. It occupies the intermediate levels of the foothills area, is abundant, and continues north to Zimbabwe.

The study was carried out on the 1,000 ha Quthing sheep stud station located about 5 km south of Quthing (Goebel et al., 1986, RD-B-42). Although the average annual precipitation is approximately 700 mm, the 1985 precipitation was only 523 mm, with 80% falling between April and September. Elevations on the sheep-stud station are from 1,620-1,910 m. A 900 m^2 exclosure was located upon a northfacing 10% slope located near the higher elevations of the station. Vegetation in the area was at one time dominated by Themeda triandra, Heteropogon contortus, and Festuca caprina on southfacing slopes, which are the more effective moisture sites. Large areas are now dominated by Eragrostis spp, Aristida spp, and Leucosidea sericea.

Four treatments to control L. sericea, in addition to a rest from grazing treatment, were initiated in the spring (October) of 1985. Shrub control treatments included cutting, spraying with 4.5 kg/ha active ingredient of 2,4,5-T silvicide, spraying with a silvicide (Reclaim), which contains 725 g/kg Tebuthiron applied at a rate of 9 kg/ha, burning individual shrubs, and complete rest from grazing.

Preliminary measurements included crown-intercept of shrubs, coppice regrowth, density of mature shrubs and shrublets, and forage production of grasses. Initial response to brush control treatments were measured in early fall of 1986. Live coppice-sprouting stem lengths of plants were recorded. Vigor of important range grasses was

Table III-G-12. Dry matter yield of grasses (kg/ha) after 2 years and 4 years.

Treatment	1983	1985
Pull	1334	1306
Spray	1520	898
Rest	1349	1016
Burn	1014	606
Mean	1304	957

Treatment means were not significantly different at the 5% level.

Source: Goebel et al., 1986, RD-B-42.

measured by the longest leaf from five randomly located plants from each plot. The number of live and dead L. sericea shrubs and shrublets per plot were counted. If a shrub had any visible green regrowth it was considered to be alive.

March 1986 measurements indicate:

- o Spring burning alone was the least effective in controlling the che che.
- o Spring cutting caused the highest mortality, but made conditions worse by increasing vigor and stem length of the remaining plants.
- o 2,4,5-T limited the decrease in density or leaf length of che che, but mostly in immature brush.
- o Reclaim (Spike) was effective in decreasing density and leader leaf length.
- o Results of fall burning plus spring burning are as yet unknown.

The project will continue. Burning, application of Reclaim, and cutting treatments were applied in March 1986.

9. Nutritive Value of Forage

a. Seasonal Changes

The quality of forage from Lesotho rangeland varies from one season to the next and from one vegetation type or plant species to another. Phosphorus is an inexpensive supplemental livestock nutrient and is expected to be very low during the winter months. Supplemental feeding of range livestock in Lesotho is virtually nonexistent. In Botswana, supplemental feeding of phosphorus in the form of bone meal has increased cattle weight gains substantially. Protein supplementation is expensive but may be necessary in situations where the natural vegetation is seasonally too low to meet the minimum maintenance requirements of livestock. Certain range vegetation types or plant species may be high in nutrients during seasons when other vegetation types or plant species are below maintenance requirements for livestock.

Rotational grazing systems and supplemental feeding programs could be devised to take full advantage of the seasonal fluctuations in the nutritional quality of range vegetation. For instance, range vegetation high in protein during winter seasons would best be reserved for winter grazing. The seasonal quality of the range vegetation in Lesotho has been determined to make grazing systems and supplemental feeding recommendations that could increase the production of Lesotho's one million animal units (Tiedeman, 1983, RD-R-34).

In 1982-83, leaf samples were harvested seasonally (autumn, winter, spring, and summer) from various vegetation types and plant

species. Samples were collected from fenced plots that had been harvested in April of the previous year. The grass species harvested from each site were:

- Mokhotlong - Cymbopogon plurinodis, Themeda triandra
- Lekubane - Festuca caprina, Andropogon appendiculatus, Themeda triandra
- Likalaneng - Themeda triandra, Harpechloa falx, Andropogon appendiculatus
- Thaba Bosiu - Hyparrhenia hirta
- Majelefa's Burn - Hyaparrenia hirta
- Molumong Exclosure 2 - Festuca caprina, Merxmuellera disticha, Harpochloa falx
- Molumong Exclosure 4 - Festuca caprina, Merxmuellera disticha, Themeda triandra
- Molumong Exclosure 6 - Cymbopogon plurinodis, Themeda triandra
- Molumong Exclosure 5 - Harpechloa falx

Samples were analyzed for crude protein, phosphorus and in-vitro digestible organic matter by Dr. Engels at Glen Agriculture College, RSA.

A second study was conducted to determine the seasonal changes in nutritive quality, not of the individual plant species but of the entire plant community of various vegetation types. All the standing vegetation except shrubs was harvested seasonally in 1976-78, from five sites. The dominant species at each site were:

Site	Dominant Grasses
Oxbow	Festuca caprina
Likalaneng	Themeda triandra
Lekubane	Festuca caprina and Themeda triandra
Mokhotlong	Themeda triandra and Cymbopogon plurinodis
Thaba Bosiu	Hyparrhenia hirta

A subsample was taken from each harvest and analyzed for crude protein and in-vitro digestibility. Crude protein values were below the minimum levels required for sheep and cattle during winter and early spring at the low mountain zone of Lesotho. In-vitro digestible dry matter was also low (below 45%) from June to October in the low mountain zone

b. Protein Values of Grasses

Little information is available on nutritive quality of the important forage species adapted to the country. If some species are higher in nutritive quality than others, then rotation programs could be planned for livestock to utilize particular vegetative sites when their nutritive values are high, and avoid sites with low nutritive productivity or supplement the grazing animals (Goebel et al., 1986, RD-B-44).

There is also a need for information on the nutritional quality of introduced grasses. Again, the critical period of winter grazing is when such grasses may be of the greatest value for Lesotho's rangelands.

Study Areas. At Mokhotlong native grasses include species of *Aristida*, *Cymbopogon*, and *Eragrostis*. *Heteropogon contortus*, *Thermeda triandra* and *Festuca caprina* are dominant on various sites. Some woody *Rhus* species are also present. *Merxmuellera disticha* are also found on some sites. The Maseru sites support stands of *T. triandra*, *E. curvula* and *Hyparrhenia hirta*. Some *H. contortus* is present, but a great expansion of the annual *Aristida congesta* has taken place with continued overgrazing. The lowest slopes of Thaba Bosiu are approximately 15 km from Maseru. *E. curvula* is abundant, as well as *H. hirta*, as on the Maseru site. Slightly higher in elevation than Maseru it also supports some woody *Rhus* species.

Methods. During 1984-85, samples were harvested in the middle of each of the seasons at various range sites within Mokhotlong. Palatable plant species were selected for sampling. Collections (leaves only) were made inside fenced exclosures.

Species Sampled. "Seboku" (*T. triandra*), a valuable forage, is abundant on fair to good condition ranges. "Lefokololi" (*H. falx*) is an extremely palatable species and one that should be more abundant on Lesotho's rangelands. It occurs in open grasslands especially on good condition ranges. "Letsiri" (*Festuca caprina*) is a normal constituent of the high mountain ranges, but is restricted to the more moisture-efficient sites like the southfacing slopes. It is classified as moderate in palatability dependent upon the associated species growing at the site. "Moseha" (*Merxmuellera disticha*) is also a densely-tufted perennial which grows on moist sites, but is normally not palatable to livestock. However, when other forms of forage are not available, or after burning, livestock will graze this species. "Leaokoana" (*Hyparrheniahirta*), "thatch grass", is a tall, robust perennial, abundant throughout Lesotho. It is mostly found on north and west slopes and is somewhat palatable, especially in the spring. Mokhotlong was the most intensively-sampled area because it has relatively more range than other districts. In addition, because of the steep mountainsides, there is more variation between range sites.

To determine the possible nutritive benefits of introducing exotic range species into Lesotho, samples of introduced and established species at Maseru were collected. Tall fescue (Festuca arundinacea) was selected for comparison to native species. It is only moderately productive on dry sites, but appeared to maintain its green color through the winter as compared to the native species.

Perennial ryegrass (Lolium perenne) also maintained its green color through most of the winter, but is slow to establish. It is a short-lived perennial but may equal annual ryegras (L. multiflorum) in productivity and is more persistent. It forms tough roots for erosion control. Because of the selective grazing nature of some animal species, separate samples of leaves and stems of L. perenne were taken. Because it is difficult to obtain stems of F. arundinacea during the winter months, the separation was not made for this species.

Results. There were no significant differences between the nutritive values of the native grasses of the mountainous sites. Crude protein contents (2-3%) were below the minimum levels required for cattle and sheep in native species during winter months (Table III-G-13). All native species averaged slightly higher crude protein in the spring months of September and October than during the summer. These slight differences were not significant. Except for H. falx there was no dramatic decrease in crude protein values from the summer to the fall. T. triandra appeared to maintain its nutritive value at a higher level than the other native grasses except during the winter months. M. disticha averaged lowest in crude protein values for the entire grazing year.

At the lowlands site of Thaba Bosiu, the abundant H. hirta illustrated a different pattern (Table III-G-14). Although this native species also indicated an overall low nutritive value through most of the grazing periods, its highest crude protein value was found during the summer months rather than the spring. However, only one sample was analyzed for each of the four grazing periods. Introduced species at Maseru were only sampled during the winter months since this was previously found to be the critical nutritive period for some native species.

Percent crude protein and production values for introduced grasses established at Maseru were variable. L. perenne leaves had the highest crude protein with a range of 13-17% and an average of 15.3% (Table III-G-14). Stems were lower, ranging from 9.6-10.2% and averaged 9.9%.

F. arundinacea stems and leaves, collectively, illustrated the variability of such a mixture. Crude protein values varied from 4-8% with an average of 5.6%. Even these relatively low values were much higher than the native species collected at Thaba Bosiu or any of the native species collected at Mokhotlong during the winter months. They were 200-300% higher while the L. perenne leaves were 800% higher than the native species.

The theoretical kg/ha of crude protein that would be available per hecatare for exotics is two to three times that from native species. Assuming complete utilization, there would be an average of 30 kg/ha of crude protein available from F. arundinacea as compared to 55 kg from H. hirta. L. perenne would produce approximately 100 kg/ha or three times as much crude protein as compared to native ranges.

10. Range Reseeding

a. Perennial Forage Introduction Trials

Six perennials were planted in January at the Maseru Station in three replications. Chloris gayana, Digitaria eriantha, and Eragrostis curvula had very good emergence and good production on inspection in July. Paspalum notatum had fair emergence and production. Both Lotus corniculatus and Tifolium pratense had poor emergence but those that emerged had good production (Tiedeman, 1983, RD-R-34).

Table III-G-13. Crude protein content (%) of major native grasses at Mokhotlong.

	Spring	Summer	Autumn	Winter	Avg.
Themeda triandra					
Site 1	4.69	4.81	5.19	3.50	
Site 3	5.75	3.25	4.56	1.75	
Site 16	7.25	4.50	4.25	1.88	
Avg.	5.90	4.19	4.67	2.38	4.28
Harpechloa falx					
Site 2	3.81	5.19	2.44	2.81	
Site 5	5.00	2.50	5.06	2.31	
Site 7	1.38	2.31	1.63	2.88	
Avg.	3.40	3.33	3.04	2.67	3.11
Festuca caprina					
Site 2	5.19	4.00	2.00	2.00	
Site 4	4.50	3.69	4.44	2.25	
Site 5	3.94	4.44	4.31	1.50	
Avg.	4.54	4.04	3.58	1.92	3.52
Merxmuellera disticha					
Site 2	5.19	4.00	2.00	2.31	2.80

Source: Goebel et al., 1986, RD-B-44.

Yields were low during the 1983 drought year for the perennials established 3 years previously at Molumong. Eragrostis curvula, lucerne, tall fescue, and Agropyron riparium were the most productive. Annual harvest yields are available from Research Division Annual Reports and two reports by Wieland (1981a, 1981b).

b. Perennial Forage Field Trials

Lucerne was planted and successfully established on three farmers' fields in Molumong. Lucerne was planted on two farmers' fields in Siloe and Nyakosoba but stand establishment was poor as a result of drought. Eragrostis curvula was planted and successfully established on two farmers' fields in Molumong and one farmer's field in each of Siloe and Nyakosoba prototype areas (Tiedeman, 1983, RD-R-34).

c. Ten Years of Reseeding Trials in Lesotho

Range reseeding trials were conducted over a 10-year period at four locations: Maseru, Molumong, Libibing, and Nyakosoba (Research Division, 1985, RD-B-35). The trials were observed and evaluated during the 1980-85 period as "most successful", "less successful", and "unsuccessful" (Table III-G-15).

Table III-G-14. Crude proten (%) and production (Kg/ha) of introduced and native grasses collected during winter 1985 at two sites within the lower elevation Themeda/Eragrostis/Hyparrhenia range type of Lesotho.

	Sample (Percent crude protein)				Production (kg/ha)	
	1	2	3	Avg	Total	Crude protein
(Introduced species, Maseru)						
Festuca arundinacea	3.88	8.00	5.00	5.62	988	55.53
Lolium perenne						
leaves	15.81	13.19	16.75	15.25		
stems	9.63	10.19	9.63	9.82		
				12.53	828	103.75
(Native species, Thaba Bosiu)						
Hyparrhenia hirta	1.50	1.44	2.44	1.79	1680	30.07

Source: Goebel et al., 1986, RD-B-44.

Table III-G-15. A summary of farming systems research seeding trials on Lesotho rangelands.

Evaluation year and site	Most successful	Less successful	Unsuccessful
Maseru			
1983	Weeping lovegrass	Smooth brome	
	Tall fescue	Buffel grass	
	Orchard grass		
	Lucerne		
	Bahia grass		
	Perennial ryegrass		
	Hairy vetch		
	White clover		
	Sainfoin		
1984	Weeping lovegrass	Rhodes grass	Smooth brome
	Tall fescue	Perennial ryegrass	White clover
	Orchard grass	Buffel grass	
	Lucerne	Hairy vetch	
	Bahia grass	Sainfoin	
Molumong			
1980	Weeping lovegrass		
	Red clover (Kenstar)		
	African millet		
	Lucerne	Cowgrass clover	
	Italian ryegrass	Alsike clover	
	White clover		
	Strawberry clover		
	Birdsfoot trefoil		
	Sainfoin		
1984	Weeping lovegrass	Red clover	Italian ryegrass
	Lucerne	(Kenland)	African millet
	Birdsfoot trefoil		
	Sainfoin		
	White clover		
	Strawberry clover		
	Cowgrass clover		
	Alsike clover		

Table III-G-15. Cont'd.

Evaluation year and site	Most successful	Less successful	Unsuccessful
Libibing 1980	Perennial ryegrass Weeping lovegrass Tall fescue (mammoth) Streambank wheatgrass Orchard grass Lucerne	Smooth brome Italian ryegrass Red clover	African millet
1984	Weeping lovegrass Streambank wheat grass Orchard grass Lucerne	Perennial ryegrass Tall fescue Smooth brome	Italian ryegras African millet Redclover (mammoth)
Nyakosoba 1985 (seeded in 1985)	Weeping lovegrass Orchard grass Tall fescue Cowgrass clover Birdsfoot trefoil Buffel grass Timothy Smooth brome Sherman big blue	Hairy vetch White clover Bahia grass	Hard fescue Rhodes grass

Note: Dates of seeding were several years prior to evaluation. Exact dates not known except for Nyakosoba (1985).

Source: Research Division, 1985, RD-B-35.

11. Educational Programs

Formal and nonformal education are an integral part of the Farming Systems Research and extension programs in range management. This effort can be separated into: publications, lectures and scientific papers, and extension activities such as meetings and workshops. Workshops were presented to extension agents in each of the 10 districts of Lesotho. Numerous pitsos were held with farmers at the three prototype areas. Demonstrations of visible differences were conducted using inside and outside exclosures to show the effects of the control of sehalahala brush (*Chrysocoma tenuifolia*) and possible reinvasion under protection from grazing vs adjacent overgrazing.

The executive summary of this section is on pages 73-81. The summary of accomplishments and recommendations is on pages 97-98.

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H. Animal Science

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H. Animal Science

1. Introduction

a. An Overview of Lesotho's Animal Industry

With over 70% of the country classified as range, one of Lesotho's major natural resources is its grassland. This resource has the potential to support a healthy livestock industry and has done so for nearly two centuries. However, the long-term future of the industry and the productivity of the resource is in question because of widespread overstocking and mismanagement. This topic is discussed in detail in the Range Management portion of this report (III-G), but because it so signficantly directly affects ruminant production, it will be referred to in this section of the report as well.

A comprehensive review of the country's animal industry was prepared by Dr. D.R. Phororo (1979) and provides a picture of the situation when the FSR Project started its program. Seven years later, many of Dr. Phororo's observations and recommendations are still true.

A common problem in the production of all grazing animals in Lesotho is the shortage of feed, especially during the winter months. This situation is compounded by the poor nutritive value of many available forages in winter, particularly the low level of protein which inhibits the utilization of plant materials for energy. Proper nutrition is basic to any animal operation and the lack of feed prevents gains being made in other areas, such as improving the genetic potential of herds and flocks through the use of superior sires. Phororo, writing about the use of improved sires to increase production, said:

> "The major difficulty in Lesotho is that both the sires and their progeny encounter an environmental resistance which is unlikely to permit the genetic potential to express itself fully ... In economic terms, it may be disputed whether it is justifiable to encourage the use of pure bred stock when it is known that most of those animals will either become sterile or die."

This concern is still valid, and the Livestock Division has a continual problem with malnutrition in their efforts to increase production through the improved sires programs. Government operated stud farms can be used to maintain sires in proper condition, but the difficulty of moving female animals to and from the sites for breeding limits their effectiveness.

(1) Livestock Numbers

Livestock numbers in Lesotho have fluctuated in response to pressures from both man and nature (Table III-H-1).

The difficulty in obtaining accurate information about animal numbers makes the reliability of these estimates uncertain for any specific year. The 20-27% annual increases reported for goat numbers for some years seem excessive. The values for horses and donkeys for 82/83 or 83/84 are obviously in error, but the data indicate that little change in total animal numbers has occurred during the last decade. Cattle numbers increased rapidly from 1976 to a peak in 1980, reportedly because of increased mine wages being brought into the country as cattle. After a ban on cattle imports was imposed in 1981, there was a steady decrease in cattle numbers that coincided with somewhat erratic increases in sheep and goat numbers.

Information from the 1970 Census of Agriculture Report (BOS, 1970), indicates there has been essentially a static number of animals in Lesotho for at least two decades. According to their records, in 1970 there were 551,520 cattle, 1,655,128 sheep, 973,767 goats, 109,703 horses, 89,711 donkeys, 4,092 mules, and 840,999 poultry in the country. There was an overall decrease of approximately 70,000 animal units in the 15 years between 1970 and 1985, but with favorable weather conditions this difference could quickly disappear. From this information it is obvious that the Basotho farmers will continue to keep as many animals as their personal situation permits unless some incentive, or an enforceable regulation to control animal numbers, is found.

Table III-H-1. Livestock inventories ('000) in Lesotho, 1974/75 to 1984/85.

Year	Cattle	Sheep	Goats	Horses	Donkeys	Chickens
74/75	512.4	1577.4	886.4	114.8	104.1	875.4
75/76	502.4	1519.7	834.6	100.3	92.7	694.3
76/77	485.5	1128.0	617.5	104.1	89.4	752.4
77/78	526.2	942.8	582.5	104.3	86.0	812.1
78/79	560.3	974.0	618.3	101.7	87.9	660.0
78/80	593.9	1043.6	784.3	101.1	85.2	826.3
80/81	590.0	1168.4	766.5	100.9	104.9	729.9
81/82	562.4	1337.4	930.4	103.1	97.4	814.5
82/83	537.5	1279.5	872.1	107.4	109.2	1051.7
83/84	529.2	1281.0	856.9	109.2	107.4	924.1
84/85	522.1	1412.2	1028.6	100.9	109.0	714.4
Average	538.3	1242.2	798.0	104.3	97.6	805.0
Ave. AU	538.3	248.4	159.6	104.3	65.1	------

Total AU yearly average for these 11 years, 1,115.8.

Source: LASR, Bureau of Statistics.

(2) Markets, Quality, and Quantity of Animal Products

Marketing animals and animal products is covered in detail elsewhere in this report, but it is worth mentioning here that the unreliable and uncertain markets have had a definite impact on the livestock industry in Lesotho. Without a premium for quality products the farmer has no economic incentive to improve production of individual animals. The existing system for marketing wool, mohair, hides, and skins does not meet the need for immediate payment to farmers, or adequately recognize quality differences. The lack of an adequate marketing system has contributed to the decline in the quality and quantity of wool and mohair during the last five decades.

Records from the Livestock Products Marketing Service indicate average yield per sheep from 1977-1983 was 2.34 kg. The highest yield was in 1977 with 2.53 kg/animal and the lowest was in 1982 with 2 kg/sheep. Mohair production followed a similiar pattern with 0.82 kg per goat in 1977 and 0.72 in 1981. The low production corresponds with drought years and is an indication of how scarce feed and poor nutrition affect production. Even in the "good" years, wool and mohair production is low, as indicated by the 4 and 3.5 kg yields produced in South Africa. Quality of wool, and especially mohair, has decreased for several decades. Premium quality Basotho Long Blue Mohair dropped from 22% of the annual clip in 1959 to 4.6% in 1977 (Wyeth et al., 1983, RD-B-25).

Lesotho is a meat importing country in spite of the large amount of grassland and sizeable inventories of animals. Thousands of sheep and cattle were imported during 1984 and 1985 (Table III-H-2). The

Table III-H-2. Cattle and sheep imports, 1984-85.

District	Cattle		Sheep	
	1984	1985	1984	1985
Buthe-Buthe	370	2,181	1,650	3,447
Leribe	1,193	2,934	6,503	16.446
Berea	469	553	1,794	2,346
Maseru	1,786	1.342	12,199	13,281
Mafeteng	602	819	16,767	12,178
Mohale's Hoek	189	319	7,032	6,301
Quthing	159	283	1,037	4,495
Qacha's Nek	-	16	612	1,390
Mokhotlong	-	-	-	50
Thaba-Tseka	-	-	-	20
Totals	4,768	8,447	47,594	59,954

Source: Livestock Products Marketing Service.

distribution of imports by district indicates the lowlands, especially the urban area of Maseru, are deficit regions, and Lesotho producers are unable to meet the demand. Some imports are purebred animals to improve breeding herds. Towns in the lowlands import the majority of slaughter animals. The national feedlot near Maseru bought animals from South Africa and this added to the number imported into that district. In addition to the sheep and cattle, during 1984 there were 49 horses, 334 donkeys, and 59 goats imported. In 1985 reported imports for these species were 136, 52, and 2, respectively. Reported exports for 1984 and 1985 combined were 1,213 cattle, 161 pigs, 1 horse, and 2 sheep.

(3) Distribution of Livestock

The import patterns are not surprising when the distribution of animals in the three ecological zones of the country is considered. The lowlands contain a higher percentage of arable land than either the foothills or mountain regions, and requires considerable draft power for farming operations. The large number of oxen make only a small contribution to the country's meat supply, and are kept at the expense of other types of livestock. Results of the survey in 1981 by the FSR Project reported by Klosterman (1981, RD-B-11) indicate the relative importance of livestock to farmers in different sections of the country (Table III-H-3).

The information in Table III-H-3 is from a relatively small sampling of the country, 173, 153, and 115 households in the lowlands, foothills, and mountains, respectively. The data are in general agreement with that reported by the Bureau of Statistics in the 1970 Census of Agriculture: more sheep and goats in the mountains with larger herds per household, increased ownership of horses in the foothills and mountains, and a high percentage of the cattle in the lowlands used for draft power. Klosterman reported 15% of the cattle in Siloe, 40% in Nyakosoba, and 26% in Molumong were females of breeding age. These values are well below the 1979 national average reported by LASA (1980), 45.9%, and the Thaba Tseka Mountain Development Project (1976), which found 41, 73, and 82% of the cattle, sheep, and goats, respectively, were breeding females. Breeding females in the sheep and goat herds in the prototype areas made up approximately 60% of the herds, while LASA reported 73% for sheep and 79% for goats.

An up-to-date indication of the composition of Lesotho's livestock herds will result from the survey conducted by the Marketing Section of the Research Division, in cooperation with an Institute for Southern African Studies project that is sponsored by the Canadian government. The results of this survey are being analyzed at the present time. In the case of cattle, a shortage of breeding females is suggested by the fact that old oxen make up virtually all the cattle sold at Livestock Division auctions. These are held at various locations in the country during the year to make it possible for farmers to sell animals without the difficult task of getting them to a distant market.

Table III-H-3. Livestock ownership in three FSRP prototype areas.

	Lowlands (Siloe)	Foothills (Nyakosoba)	Mountains (Molumong)
Households with stock (%)	74.6	82.4	91.3
Cattle			
% of total H.H.	39.3	56.2	61.7
Range in No./H.H.	1-12	1-43	1-37
Mean No./herd	3.5	7.7	7.3
Draft Animals			
% of total H.H.	31.2	51.0	50.4
Range in No./H.H.	1-7	1-13	1-12
Mean No./herd	2.8	4.5	4.0
Sheep			
% of total H.H.	17.3	19.0	32.2
Range in No./H.H.	2-70	1-102	2-308
Mean No./herd	16.0	24.1	41.9
Goats			
% of total H.H.	26.0	18.3	27.0
Range in No./H.H.	1-91	1-86	1-124
Mean No./herd	9.5	13.9	26.2
Horses			
% of total H.H.	12.7	47.7	47.0
Range in No./H.H.	1-3	1-10	1-11
Mean No./herd	1.4	2.3	2.3
Donkeys			
% of total H.H.	19.1	23.5	29.6
Range in No./H.H.	1-6	1-5	1-9
Mean No./herd	1.9	1.8	2.1
Poultry			
% of total H.H.	48.6	65.4	85.2
Range in No./H.H.	1-100	1-26	1-57
Mean No./flock	7.5	6.6	8.4
Pigs			
% of total H.H.	28.3	38.6	7.8
Range in No./H.H.	1-10	1-3	1-3
Mean No./herd	1.5	1.2	1.6

Source: Klosterman, 1981, RD-B-11.

Certain cultural practices influence livestock and livestock products output as well as the management of the animals. One custom that is particularly relevant to cattle, sheep, and goat management is what is called "mafisa". Mafisa is described by Klosterman (1981):

> "Mafisa is a custom whereby animals are loaned to or shared with others for a variety of reasons. An owner may mafisa animals out to obtain access to herders or better grazing, whereas, the recipient obtains use of the animals and certain limited products. From the viewpoint of animal production, this practice would seem to be to the advantage of the owner. However, for the recipient without access to draft power, fuel, milk, etc., it can be quite beneficial."

The practice is widespread throughout the country and some indication of the numbers of households and animals involved can be obtained from data collected in the baseline survey in 1981 as reported by Klosterman (1981, RD-B-11) (Table III-H-4).

Farmers in the lowlands prototype area, Siloe, mafisa'd out considerably more cattle, sheep, and goats than were brought in by this method. Grazing is limited in this region because it contains a higher percentage of cultivated land than the other two areas. The other two areas had considerable, approximately equal numbers, in both the "in" and "out" categoriees, except that many more sheep and goats were mafisa'd out than in at the foothills area of Nyakosoba.

Table III-H-4. Livestock mafisa'd, FSRP prototype areas.

	In			Out		
Species	Siloe	Nyakososba	Molumong	Siloe	Nyakosoba	Molumong
	(Percentage of households participating)					
Cattle	5.2	19.6	25.2	11.6	16.3	15.7
Sheep	2.3	2.6	5.2	6.9	11.1	7.8
Goats	1.7	1.3	3.5	10.4	9.2	4.3
Horses	2.3	6.5	8.7	2.3	9.2	8.7
Donkeys	2.9	3.3	1.7	3.5	3.3	5.2
	Total number mafisa'd and (maximum number per household)					
Cattle	21 (4)	106 (9)	80 (7)	48 (7)	102 (15)	62 (13)
Sheep	15 (7)	24 (15)	56 (17)	81 (18)	158 (35)	79 (20)
Goats	36 (19)	22 (17)	27 (15)	89 (20)	107 (20)	34 (18)
Horses	5 (2)	17 (4)	23 (9)	4 (1)	24 (3)	15 (2)
Donkeys	5 (2)	6 (2)	5 (3)	9 (4)	6 (2)	18 (10)

Source: Klosterman, 1981, RD-B-11.

The movement of animals to and from the mountain cattle posts for summer grazing is an important part of the livestock management system in Lesotho. It is practiced to a greater degree by farmers in the foothills and mountains. Eighty-six to 90% of the farmers in the mountain prototype area of Molumong sent either cattle, sheep, goats, or combinations of these to a cattle post during the 1979-80 season, as did 50-60% at Nyakosoba. In contrast, only 6-10% of the livestock owners at Siloe sent any of these animals to the mountains for summer grazing.

Livestock movement, or lack of it, has implications for the management of the animals that should be considered when investigating methods to improve production for various regions of the country. Animals in the lowlands, and to a considerable degree in the foothills, must be fed from feed sources grown in the area. The need to rely solely on local feed supplies is also increasing in many mountain regions as more and more people live there on a year-around basis. In the lowlands the problem of finding animal feed is compounded by the high percentage of the land under cultivation and not available for grazing during the growing season. After the crops are removed the residues must be shared with livestock brought back from the cattle posts for the winter.

In effect, the farmers in Siloe must manage their herds and flocks on the resources available within the prototype area, while those at Molumong have additional summer grazing available. The foothills fall between these two extremes. Permanent residents of the mountain areas face the problem of obtaining winter feed for their livestock. The long, cold, dry winters, limited land area for forage production, the distance to feed sources, and the poor nutritive value of bleached and weathered native grasses make this a difficult obstacle to overcome.

(4) Dairy

There are a large number of cows milked for at least a few months of the year, but most milk is used by the owner or sold for local consumption, and the production per cow is low by most standards. A few commercial dairies are operating in the lowlands and tend to be concentrated in the Maseru area. There is considerable interest in developing the dairy industry in Lesotho and dairy products would make a valuable addition to the nutritional food base of the country. In order for the industry to develop into a major food supplier, a source of feed must be available in sufficient supply and at economically feasible prices to permit year around production. In addition to the production, improvements must also be made in the handling and storage of milk and milk products by wholesalers and retailers.

(5) Horses and Donkeys

Horses and donkeys are important beasts of burden in Lesotho, and in the mountain regions a principle mode of transportation. There are approximately 100,000 of each species in the country. The ownership of horses among foothill and mountain dwellers is nearly 50% while in

the lowlands it is 12-20%. Donkeys are more evenly distributed with 20-30% of all households owning at least one of the animals. Horses and donkeys are seldom used for cultivating crops and are not an important source of draft power.

During the early part of the 19th century a breed known as the Basotho pony developed in the country and were known for their endurance, good temperament, and sure-footedness in mountain terrain. Cross-breeding and selling the better specimens for cavalry mounts during the Boer War was very detrimental, but a few good representatives of the breed remain. The Irish government is sponsoring a breeding program to improve the Basotho pony and to help it regain its desirable characteristics. A breeding farm is located near Thaba Tseka and a training and sales operation is combined with a riding stable near the Molimo-Nthuse lodge on the Blue Mountain Pass road.

(6) Poultry

Most of the livestock enterprises in Lesotho involve grazing animals, but poultry is an important element in the animal industry of the country. Keeping a few chickens is a common practice in most villages. In the prototype areas, 85% of the households in Molumong, 65% in Nyakosoba, and 49% in Siloe reported having chickens. Average flock size was 6-8 birds with one farmer in the Siloe area having 100 laying hens. The "native" birds are of mixed breed, but the heavier meat breeds tend to dominate. Eggs are produced for home use and sale to villagers. Seventy percent of the households surveyed in Molumong produced all or most of the eggs consumed, and 25% reported selling eggs. Disease control, especially Newcastle disease and coccidiosis, and obtaining the high energy protein feed needed by chickens, are two serious problems for the village poultry producer.

A sizeable commercial poultry industry exists in Lesotho in addition to that in the villages. This is geared to egg production and consists almost exclusively of laying flocks. Production is centered in the Maseru district with few flocks found outside the lowlands. Feed is purchased from South Africa, as are the chicks. Imports for poultry in 1984 were 252,388 birds, most of which were pullets. Nintey-six percent of the birds in 1984 and 89% of the 202,000 imported in 1985 came into the Maseru district. Larger producers belong to the Poultry Association and get help through the Livestock Division for feed delivery, health care for the birds, poultry housing construction, credit, and assistance to buy chicks. To belong to the Association a producer must have housing for the birds that meets certain specifications, attend a course in poultry management, and be approved by Association members living in his/her district. These regulations are enforced more rigorously in the lowlands, especially in the Maseru area, than in the mountains.

All poultry products from members must be sold through the Association which has retail outlets in Maseru and some larger villages in the country. These are primarily confined to the

lowlands. Quality control is a problem, especially in warm weather, because refrigerated storage and transport are not available. The marketing system appears to work in the collection process, but movement to areas of demand is inadequate. Researchers found eggs to be in short supply in villages near where Association members had flocks. Poultry Association members reported trouble in selling eggs during 1985-86, which also suggests a distribution problem. Egg marketing is further complicated by the regulated price of approximately 20 lisente more per dozen than in South Africa. The price control is enforced by a ban on the importation of eggs and the requirement that Association members sell through official channels.

While egg production is the major poultry enterprise in Lesotho, there is overwhelming interest in raising ducks for meat. The Livestock Division maintains a small flock of ducks and some of the donor projects, such as the Catholic Relief Services, have had trials with rearing ducks on fish ponds and irrigation impoundments. Obstacles to the development of the industry are similar to those of other types of poultry. To raise ducklings to marketable size a feed containing approximately 16% protein is required. This is not available in the country and must be imported. Although there may be certain situations in Lesotho where duck rearing could be profitable, the likelihood of it becoming a viable industry or being a significant factor in helping the country reach food self-sufficiency appears doubtful at this time.

(7) Swine

Swine farming in Lesotho is a minor enterprise when compared to grazing animals. The FSR baseline survey found 28% of the households in Siloe, 39% in Nyakosoba, and 8% in Molumong kept pigs, but the average number per household was 1.4 animals. There are a few good-sized operations in the lowlands, and these account for most of the pork products produced in the country. The need to rely to a large extent on imported feeds is a serious problem for farmers to overcome in a small-scale operation. The latest livestock inventory from the Bureau of Statistics recorded 53,031 pigs. It is unlikely that swine production will become a major industry in Lesotho.

(8) Fish

Trout were introduced into the mountain streams of Lesotho during the last century. They thrived in most of the waters, but are insignificant as a food source for the country. In more recent years there has been interest in establishing a fisheries industry based on warm water species, carp or catfish. The increased attention given to the possibility of irrigation from artificial collection ponds also sparked interest in rearing fish. Experiments with carp (species unknown) produced growth from fingerling to approximately 0.5 kg in 1 year if supplemental feed was supplied. The lack of water in much of the country is an obvious problem and in times of scarcity a choice may have to be made between the fish and other uses of the water. Problems associated with fish rearing include obtaining healthy

fingerlings, control of predatory birds, escape prevention if the pond overflows, disease control, and keeping fish out of the irrigation system if the impoundment is also used for watering crops. At this time there is limited fish production in Lesotho (Table III-H-5).

Research into yearly water temperature fluctuations, the effect of extremely muddy water on the growth of plankton, the quantity of natural foods present in catchment ponds, water chemistry at different sites, and a survey of diseases endemic to Lesotho is needed before the potential for a fisheries industry can be estimated.

(9) The Livestock Division of the Ministry of Agriculture

The Livestock Division has a broad mandate that includes all aspects of animal production except research. It is headquartered in Maseru and has officers in each of the 10 districts (District Livestock Officers). It is a production-oriented unit and is involved in several programs to improve the production of animals and animal products. It does not do research, but is involved in many extension activities. Some activities of the Livestock Division are listed below.

Animal Health. The Division maintains a veterinary clinic and diagnostic service that monitors the incidence of disease in the country's herds and flocks. A preventative program includes such services as maintaining and operating dipping stations for cattle, sheep, and goats (dipping sheep for scab control is required by law), vaccination of animals, and maintaining a supply of veterinary supplies for sale to livestock owners. A unit, in conjunction with Extension, conducts educational programs for farmers on disease prevention and animal health concerns.

Table III-H-5. Fisheries production (1978-79 to 1983-84).

Year	Total pond area	No. ponds	Gross production[1] (kg)	Net production (kg)	Feed fed (kg)
78/79	11.3	56	19,290	8,315	32,074
79/80	11.0	50	13,526	7,088	26,519
80/81	5.5	29	5,187	2,937	7,859
81/82	----- data missing -----				
82/83	22.6	102	18,493	11,289	28,732
83/84	11.4	51	11,300	9,457	15,240

1. Includes production from the Livestock Division's ponds at Maseru.

Source: 1975 Lesotho Agricultural Situation Report.

Improved Sires Program. The Division has undertaken to improve the genetic make-up of the country's livestock herds by importing purebred rams, billies, and bulls. Farmers' needs in each district are determined by the District Livestock Officer. The division summarizes the requests from the entire country and purchases the requested animals. Almost all imports are from South Africa. The superior sires, and a small number of females, are then distributed to the farmers and organizations that ordered them. Studs are also maintained at various locations in the country where sires, especially bulls of superior breeding, are kept for use by livestock owners in the area.

Livestock Associations. The division provides guidance and acts as a regulator for livestock associations in the country. Two of the largest are the Wool/Mohair Growers and the Poultry Association. Associations tend to be for the larger producers and certain benefits accrue to members. For example, farmers belonging to the Wool/Mohair Growers Association do not have to pay cash for having their animals treated for external parasites at government-operated dip tanks. Their charges are deducted from the receipts for the sale of wool and mohair, while non-members are charged 20 lisente/animal cash. To belong to the association, a farmer must have a minimum of 50 breeding ewes and/or does. The number of producers belonging to the Wool/Mohair Growers Association has increased from 1,451 in 1981/82 to 3,183 in 1985.

Members of the Poultry Association receive advice from Livestock Divsion personnel in addition to the other benefits cited earlier. The division maintains a laying flock and chick-rearing facility at its Maseru headquarters.

National Feedlot and Abattoir. A national feedlot and abattoir were established in the early 1980s as part of a development program to stimulate meat production. The feedlot has operated for several years, but not at the anticpated level of 6,000 animals annually. Cattle purchased in Lesotho were almost entirely of 10 to 15-year-old oxen. Some younger animals suited to finishing in a feedlot were imported from South Africa.

The abattoir was completed in 1981, but did not start operations until the autumn of 1985. At that time the management of both the feedlot and the abattoir were made the responsibility of a project sponsored by the Danish government. Both units are reported to be operating at a profit, but in terms of a domestic beef industry, the availability of suitable cattle from Lesotho remains an unanswered question. Some sheep are being fed on a trial basis at the abattoir.

Livestock Products Marketing Service. The Livestock Division has an active program to market animal products. It maintains approximately 80 wool sheds that are located in every district. Shearing crews operate at these wool sheds during October/December clipping sheep, and during March/May shearing goats. The wool and mohair taken at the sheds is sold through the LPMS marketing system.

Very little grading or sorting of the raw material is done in Lesotho and the bulk of the wool and mohair is sold through South African markets. Virtually no processing is done in the country.

Hides and skins can also be sold by farmers at the wool sheds, but few go through the official marketing channels. In 1984 the official record shows 1,421 hides and 5,219 skins exported from an estimated 70,000 cattle and 350,000 sheep that were slaughtered or died.

Other activities of the Livestock Division include the operation of a dairy processing plant, a pig farm, a fisheries program in which brood stock of carp and catfish are kept to produce fingerlings, and a facility for rearing and slaughtering ducks for meat.

(10) Domestic Feed Sources

The major sources of animal feed concentrates in Lesotho are the maize milling operation at Maputsoe in the northern lowlands and the Lesotho Flour Mills at Maseru. Approximately 10,000 t of maize bran, locally called hominy chop, and screenings are produced annually, along with 2,000-3,000 t of wheat bran. It is ironic that with animals literally starving to death a large percentage of the hominy chop produced in Lesotho is exported to South African stockmen. (The feedlot now purchases it directly from the mill.) Hominy chop is an excellent energy source with about 90% TDN or 3.6 megacalories digestible energy/kg and 7% digestible protein. It is a well known feed in most parts of the country.

In addition to wheat and maize brans, there is some distiller's grain from brewerys available for livestock feed, but the amount is limited and is available only in areas near the production site. At the village level, the by-product from making the traditional sorghum beer, joala, is fed to pigs and should be investigated as a source of feed for poultry.

The production of forages by farmers is increasing and interest in growing hay for the winter months is high among prototype livestock owners (Fig. III-H-1). The use of exotic species of grasses that have superior nutritive value during the winter months looks promising to improve winter pastures. These are practical ways to improve the diets of herbivores and can be done with available resources. Both are discussed in detail in the Range Management section of this report.

The lack of a protein source in Lesotho that is economical to use in animal feeds is a basic problem in the production of all species. The use of non-protein nitrogen sources such as urea for ruminants would help overcome this obstacle, but the dangers of toxicity unless these compounds are properly used must be carefully considered. A commercial product that is available from South Africa and sold under the name of "Rumevite" contains a wide range of minerals and protein along with some urea. It is sold in blocks that limit intake and in a powder form for mixing with grain. The product is known to the majority of Basotho farmers and is used by many.

It must be remembered, however, that sufficient calories must be supplied to animals in order for protein supplementation to have any positive effect. Getting adequate amounts of feed to supply needed energy is the first priority for helping many of Lesotho's animals, especially during the winter.

2. FSR Project Animal Research

a. Previous Research

When the FSR Project began in 1979 there had been some research with animals reported in the literature, but much of the work up to that time was by development projects. Trial feedlots were included in the programs of the Leribe-Khomakhoana, Senqu, and Thaba Bosiu projects, and they and others such as the Thaba Tseka project investigated the use of associations to improve the condition of both animals and the rangelands. These efforts met with little permanent success for a variety of reasons, but one underlying problem was the lack of understanding, and in some cases the lack of involvement of livestock owners. In most cases, cattle feeding trials were with mature oxen, since younger stock were not available in Lesotho and had to be imported from South Africa. When adequate rations were fed, the animals gained weight. Participating farmers showed much interest in the trials, but very little, if any change occurred in livestock manangement.

Investigations into sheep management during the 1970s tended toward parasite control and improving the nutrition of breeding animals. Fitzsimmons (1971) refers to the mountains of Lesotho as mineral-deficient areas and stresses the need to provide a mineral supplement. He also cites evidence on the value of worm control in sheep and goats. As with cattle, little impact was made in changing traditional management practices.

This lack of success in getting farmers to feed their animals in spite of successful demonstrations and professed interest was of importance to the FSR project. Klosterman reports in RD-3-13, 1982:

> "Of particular interest to Farming Systems Research is why farmers have not adopted more of the small, feedlot technology. Trials by the various projects have clearly demonstrated the benefits of improved feeding and that significant weight increases of mature, cull oxen can be attained economically. An obvious answer might be the lack of a good national market. However, reference is made in some reports to good demand by local butchers for the limited numbers of cattle available. Perhaps the use of maize grain, by-products and purchased supplements in fattening rations does not appear feasible to the average farmer.
>
> "It is quite clear from previous development efforts, if permanent improvements in livestock production are to be realized, it must be done by farmers with their animals,

resources, desires and abilities. Communication demonstrations are not enough. If farmers do not do it, it will not be done. Therefore, it is recommended that very little or no effort be expended on typical, on-station livestock research."

Animal research was conducted during the first 4 years of the project while an expatriate advisor was on the FSR Project team. A serious shortage of Animal Science Section personnel during the last 2.5 years prevented the continuation of an agressive animal research program. A special thanks is due Victor Ramakhula, Range Section Leader, for his support and active role in the initiation and implementation of animal trials conducted during the last 2 years of the project. The Range and Animal Science Sections of the Division had a combined program during the project's 2-year extension with Carl Goebel serving as advisor for both. The FSR Team Leader participated to the extent his administrative duties allowed.

The Research Division has no facilities for conducting research with animals, except holding pens for adult poultry, and has had to borrow them from Lesotho Agricultural College (LAC) or the Livestock Division. Information about the FSR Project's animal research is detailed below by species.

b. Cattle

In keeping with the farming systems philosophy, research was conducted with farmers to find solutions for immediate problems they faced in managing their cattle. To a large degree this was as much or more of an extension effort as it was true research. Feeding trials were conducted in cooperation with LAC to provide better control over experimental conditions than was possible when animals were kept at a village or farm.

(1) Assessing the Value of Rumevite for a Winter Supplement.

The protein/mineral supplement was fed in block form by farmers to their cattle during the 1981 winter months (Fig. III-H-2). No measurable benefit from feeding the protein/mineral supplement was found. This lack of response was attributed to a severe energy deficiency due to inadequate winter grazing and lack of fodder. Under such conditions feeding a small amount of protein and minerals would not produce a measurable benefit (Molapo et al., 1982, RD-B-12).

(2) The Use of Hominy Chop as an Emergency Winter Feed.

Winter feeds are normally in short supply in Lesotho and in the drought years of 1982 and 1983 the situation was critical. Cooperating farmers in the prototype areas were told to feed a double handful of hominy chop (bran from the milling of maize), to one-half their oxen each day. The other oxen were to act as controls in the study and to demonstrate the value of supplemental feeding. Twenty farmers with 72 oxen participated in the study. The trial did not result in weight differences between fed and control oxen because farmers either worked the fed animals more or fed all their animals

Figure III-H-1. A farmer gathers weeds to use as winter fodder in the Nyakosoba prototype area.

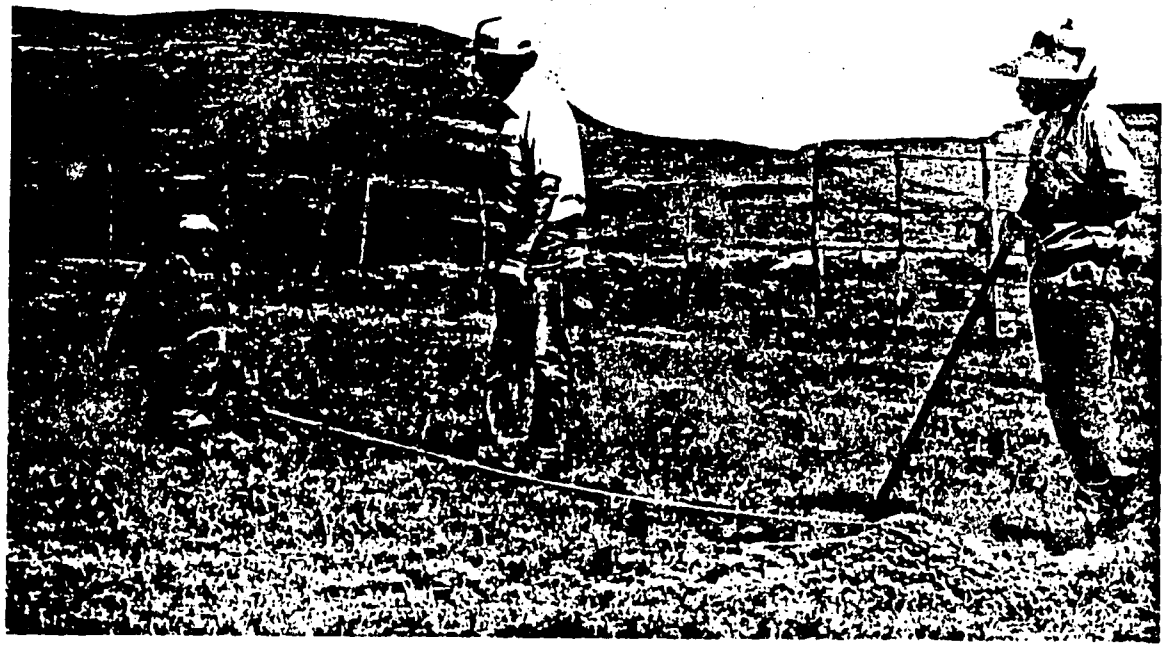

Figure III-H-2. Cattle owners in the Siloe prototype area begin construction of cattle holding pen to be used in the Rumevite supplement experiment.

when it became apparent that feeding hominy chop was beneficial. The study was a success in getting farmers to appreciate the value of feeding oxen and Klosterman writes: "It might be said that the battle of conducting a controlled experiment was lost but the war of introducing a new feed was won." (Klosterman, Livestock Circular No. 6, 1983)

(3) Introduction of Fodder Production.

Feeding Rumevite and hominy chop to animals during the winter months and the constant contact with livestock owners that took place enabled the researchers to encourage fodder production. In 1983 some farmers grew winter grain for fodder and their cattle wintered in much better condition than in previous years. A field day was held with two participating farmers as key speakers. This was one of several activities involving the Farm Management, Extension, and Range Sections, as well as Animal Science, that promoted the production of fodder for animals. An economic analysis of the value of fodder production (Holland et al., 1984, RD-R-39) indicates excellent returns on the crop. In addition, some farmers were able to earn extra income from custom plowing because their oxen were in good enough physical condition to do the work.

Encouraging farmers to produce fodder has been a continual effort of the project. Demonstration plots of fodder sorghum (sudangrass hybrids) in the Siloe prototype area during the 1984-85 cropping year inspired over 67 farmers to form a fodder association and use their own resources to plant a total of 20 ha of fodder during the 1985-86 year. Interest is high in the other prototype areas and fodder production is increasing yearly. In the lowlands, where the only grazing is on land between cultivated fields and on crop residues after harvest, fodder production is especially important. Victor Ramakhula was instrumental in increasing fodder production.

(4) Cattle Feeding Experiments.

Prior to the FSR Project, cattle feeding studies had been done in commercial-sized lots. Klosterman et al. (1985) note, "Little or no research has been directed toward simple rations and methods of feeding which could be adopted by small farmers using their present facilities." The Research Division/FSR researchers conducted two trials using simple rations composed of ingredients available to Basotho farmers. Both trials were done in cooperation with the Lesotho Agricultural College using pens at the college to hold the animals.

The first experiment from May to October 1982 compared a grass hay diet with one containing lucerne. Young Freisian, Brown Swiss, crossbred cattle of both sexes, and cows from the LAC dairy herd were used (Table III-H-6). Each treatment group contained seven animals and received either Diet 1 (2.22 kg grass hay, 1.09 kg wheat bran, and 3.39 kg hominy chop) or Diet 2 (2.22 kg lucerne hay and 4.28 kg hominy chop). Animals on Diet 1 received a mineral supplement and salt while the ones on Diet 2 (lucerne hay) had access to only salt.

The authors caution that because of the variable breed and ages of these cattle, these results should only be considered as an indication of what the performance of the two diets would be if fed to a larger group of more uniform cattle. The results did show that a simple ration of ingredients found in Lesotho could successfully be fed to cattle.

A second feeding trial compared the gains of mature oxen, the type of cattle available in Lesotho, with young steers. Six steers, approximately 8 months old and of similar weight, were selected from the college herd. Six mature oxen of unknown ages were purchased at the Thaba Tseka auction. They were trekked to Maseru, dehorned to enable them to eat from the feeding facilities, and pastured at the college until the trial started in May 1983 (Table III-H-7). Feed costs per unit of gain in the mature oxen were over three times what it was for the young animals, and illustrate the basic problem of attempting to produce meat from these animals.

c. Sheep and Goats

Small stock are an important part of the livestock industry, and are used for meat and cash sales of products to a larger extent than cattle. Serious problems facing producers are the low reproductive rate, and the low yield of wool and mohair per animal. A major cause of this low productivity is a shortage of feed that results in severe malnutrition, especially during winter when ewes and does are pregnant. Klosterman fed some ewes hominy chop during breeding and again at lambing time, but found that the shortage of feed was so critical that there was no positive effect on conception or live lambs born (Klosterman et al., 1984, RD-B-29).

Table III-H-6. Rations for growing-finishing young cattle.

	Grass hay	Lucerne hay
No. days fed	170	170
Initial weight (kg)	173.6	166.4
Final weight (kg)	270.0	310.0
Average gain/head (kg)	96.4	143.6
Average daily gain (kg)	0.57	0.84
Average daily feed (kg)	6.7	6.5
Kg feed/kg gain	11.8	7.69
Feed cost/kg gain (Maloti)	1.5	1.3

Source: Klosterman et al., 1985, RD-B-30.

A study to determine the benefits of a light stocking rate and limited supplemental feeding was planned and implemented in a joint effort by the Range and Animal Science Sections of the Division (Tiedeman et al., 1983, RD-B-19). The study was conducted at the Lekubane Range Research Substation. This substation is 2,200-2,600 m elevation and consists of three fenced grazing areas which total 364 ha. Frosts occur at all times of the year and mean annual rainfall is 800-1,000 mm. The area is typical of much of the mountainous regions of Lesotho. Most of the range inside the fenced substation was judged to be in fair condition, while the surrounding communal range was rated poor.

Villagers in the area expressed an interest in improving the condition of their animals and nine from the local wool grower's association agreed to cooperate in the trial. Each farmer brought 20 ewes to the station where they were divided into treatment groups and ear tagged for identification. Half the ewes from each cooperator were kept at the station and either received Rumevite mineral/salt summer supplement and a protein/mineral winter supplement while on a lightly stocked pasture, or were grazed on the lightly stocked pasture with only supplemental salt. The other half of the 180 sheep were tagged and taken back to their owners' homes and grazed in the traditional manner on communal range. The trial started in January 1982, and has been continuing, with some modifications since. The sheep were sheared in November and the wool production from the ewes in 1982 and 1985 is shown in Table III-H-8.

Table III-H-7. Profitability of fattening cattle of different ages.

	Young steers	Mature oxen
No. days fed	155	127
Ave. Initial wt. (kg)	135	491
Ave. Final wt. (kg)	303	553
Ave. gain/head	168	62
Ave. daily kg feed		
Maize stove	2.93	4.71
Wheat bran	1.00	1.04
Hominy chop	4.29	6.71
Rumevite	0.08	0.10
Feed/day/animal	8.30	12.56
Kg feed/kg gain	7.64	25.84

Source: Klosterman et al., 1985, RD-B-30.

The economics of producing approximately 0.5 kg more wool per sheep by supplemental feeding have yet to be determined. This represents about M1.25-1.50 additional income per animal at present prices. The records of feed intake and production figures for much of the 4 years were lost, so an analysis of the economics was not possible. It is now known that the native vegetation in the mountains contains very low levels of protein and phosphorus for 4-5 months during the winter, and a lengthy period of supplemental feeding is necessary. The reproductive rate from ewes was greatly improved when supplemental energy and protein were fed. The national reproductive efficiency for sheep is approximately 40%. The 45 ewes placed on the lightly stocked range (1.5 ha/sheep) produced 30 (67%) weaned lambs and those on the same range and receiving supplements weaned 33 (73%). During the 1985-86 season 90 ewes that were given both energy and protein supplements during the winter weaned 80 lambs, an 89% reproduction rate. The lambs weighed 20.8 kg at weaning which is the same weight reported in 1983 by Tiedeman et al. (RD-B-19).

No data were available about the reproduction of the sheep kept at the cooperators' farms, but from observations and conversations

Table III-H-8. Average fleece weights, sheep feeding trial.

	1982				1985			
	Lightly stocked, fed Rumevite		Overstocked communal range		Lightly stocked, fed Rumevite		Overstocked communal range	
Farmer	Average fleece (kg)	Number of sheep	Average fleece (kg)	Number of sheep	Average fleece (kg)	Number of sheep	Average fleece (kg)	Number of sheep
N.L.	2.37	4	2.26	10	3.41	9	2.61	9
M/N.L.	2.43	3	1.93	5	2.71	9		
K.K.	2.88	5	2.14	10				
L.T.	3.46	8	3.02	16	3.10	8	2.76	9
M.R.	3.44	5	2.87	10	3.58	10	2.90	9
K.R.	3.35	7						
M.M.	3.58	7	3.35	10	3.66	9	3.16	10
H.K.	3.06	5	2.83	10	3.08	10	2.42	10
Average	3.19	44	2.71	71	3.26	55	2.77	47

The sheep on the lightly stocked range only did not produce significnatly more wool than the ones on communal range and results are not shown.
Wool weights were obtained for only part of the sheep on trial.
(Differences between wool production from the supplemented ewes and those on communal range are significant at P=0.05).
Ewes received 0.15 kg hominy chop/day and the protein/material Rumevite mixture during the 1984/85 winter.

with them it was probably near the national average, 40%. However, as is evident from the wool yields, production varies considerably among livestock owners. The reasons for this vary with the situation, but better management and superior genetics in some flocks are undoubtedly key factors.

In 1983, the cooperating farmers and the researchers decided to alter the trial by including goats. These were held at the station and managed in the same way as described for sheep. Kid mortality and other reproductive disorders in goats are major problems in Lesotho. Nutritional deficiencies are considered to be a major contributing factor. Angora goats, the only breed that is allowed to be imported into the country, are sheared in April and May, so the results of supplemental feeding on mohair yield are not available for this year. The mohair yields in previous years were essentially the same, slightly less than a 1 kg/goat, for all groups. There was an improvement in the percentage of weaned kids, even though the reproduction rate was still low. To summarize the results of the 1985 breeding season:

Abortions, 8/57 (14%)	Births, 45/57 (79%)
Twins, 4/57 (7%)	Kid mortality, 12/45 (27%)
Kids weaned 33/57 (58%)	

The better management, especially improved nutrition, increased the reproductive rate 15-20% over the annual national average of 35-45%. The kids averaged 12.9 kg at weaning, which is slightly more than one-third the mean doe weight, 31.5 kg. The final outcome remains to be seen, however, as many kids die during the first cold weather of the season.

This trial has shown that with supplemental feeding and proper management the production of both wool and lambs can be increased in sheep and the reproductive rate of goats improved. The economics of using supplements remains to be analyzed. Perhaps the greatest benefit from this study is the role it played in educating the farmers about the advantages of supplementing their animals during the winter and providing them with good grazing in the summer. Their knowledge and appreciation of disease and parasite control was increased because all animals in the trial were dosed for internal parasites, dipped for external ones, and vaccinated against pulpy kidney. The group is very enthusiastic and wants to continue to manage part of their flocks in the same way as was done during the trial. They have offered to pay for the caretaker to help keep the trial going.

d. Egg Production From Small Flocks

Most attention has been given to developing and improving the grazing animal industries in Lesotho, but there was considerable interest by prototype area farmers in rearing poultry, primarily laying hens. As stated earlier, most of the Livestock Division's efforts with poultry have been with large commercial flocks of laying hens. A trial was conducted cooperatively by the Animal Science, Range Management, and Farm Management Sections in 1985-86 to assess:

- the performance of an improved breed of layers with that of native birds when managed by farmers in small flocks;
- ability of farmers to manage a small poultry flock;
- the problems encountered by a farmer in obtaining inputs;
- if a market existed in the villages for locally produced eggs; and
- the economics of egg production under village conditions.

Eight women farmers, three in the Nyakosoba prototype area and five at Siloe, were selected to be cooperators in the trial. They were selected on the basis of an interest in poultry production, the willingness to construct, or utilize an existing structure to shelter the birds, and ownership of some native chickens. The project purchased wire netting and posts, feeders, waterers, and storage containers for the feed. Vaccines were obtained from the Veterinary Clinic of the Livestock Division and distributed to the cooperators as needed. Each farmer was given a record book and instructions about the type of information needed by the reseachers. They were also given instructions about how to give the birds medication and treat them for external parasites. Both the native and improved birds received prophylactic treatment against Newcastle disease, which is endemic throughout Lesotho. Complete starter, grower, and layer

Table III-H-9. Egg production and feed consumption of layers in small village flocks[1]

	Total egg production (dozens)		Total feed consumed (kg)[2]		Kg feed/dozen eggs	
	Improved breed	Native birds	Improved breed	Native birds	Improved breed	Native birds
Man.	727.6 (48)[3]	46.1 (10)	1760	472	2.4	10.2
Mai.	749.5 (46)	46.0 (16)	1571	638	2.1	13.9
Mak.	678.8 (48)	24.6 (8)	1711	357	2.5	14.5
Ran.	589.5 (50)	83.5 (15)	1703	400	2.9	4.8
Mon.	662.6 (50)	66.0 (12)	1574	407	2.4	6.2
Mol.	485.8 (39)	100.2 (12)	1518	521	3.1	5.2
Les.	359.5 (43)	66.0 (9)	1557	507	4.3	7.7
Moh.	446.6 (49)	78.2 (13)	1654	528	3.7	6.7

1. Egg production is from the start of lay in August.
2. Feed consumption includes from 9 weeks through the trial.
3. Number of hens at the end of the 31 week period.

mashes were used in the trial in order to standardize the feeding regimen among the eight farmers. The feed was purchased from local suppliers and delivered to the cooperating farmers as needed.

Day-old pullets of the Isobrown breed were purchased from a hatchery in South Africa and held at the Livestock Division's poultry plant for 9 weeks. Fifty pullets were given to each of the cooperating farmers 21 Apr 1985. They began to lay in August. The native birds owned by the farmers were mixed breeds of varying ages, although most were young hens. From two to four roosters were kept with hens of both native and improved breeds in all the flocks. Production was measured for 31 weeks and feed consumption was calculated for the entire period to 30 Jan 1986 (Table III-H-9).

Differences in management skills among the cooperating farmers were observed during the trial and this is reflected in the eggs produced by the improved breed of chickens. Profitablity of the enterprise was tied closely to the egg production. When feed consumption and costs are expressed as kg/dozen eggs, or feed costs per dozen, the differences are readily apparent.

	Average (range)
Dozen eggs/hen	
Improved breed	12.6 (8.4-16.3)
Native birds	5.4 (2.9- 8.4)
Feed costs/dozen eggs (Maloti)	
Improved breed	1.11 (0.84-1.71)
Native birds	2.98 (1.90-5.76)
Ave. cost of feed (Maloti/kg)	0.397

The average amount of feed required to produce a dozen eggs was 28 kg with a range from 2.1-4.3 kg. The cost of the feed averaged M0.397/kg during the experiment, which is a mean feed cost of M1.11 for each dozen eggs with a range of M0.84-1.71. The top four farmers' feed costs averaged M0.98/dozen eggs, while the other four fed M1.44 of feed for each dozen eggs.

The native birds were poor egg producers in comparison with the Isobrown breed, and in all cases feed conversion into eggs was low. Feed costs per dozen eggs ranged from M1.90-5.76. These birds were primarily meat-type breeds and displayed a strong tendency to brood after laying a clutch of eggs. Several broods of chicks were hatched and the young birds' consumption of feed was partially responsible for the inefficiency in egg production by the native birds. No attempt was made to determine the number of young birds produced, but these would offset some of the apparent costs. The native birds were valued at M5.00 each at the end of the experiment and because of their smaller size, the Isobrown birds at M4.50.

In addition to feed costs, disease prevention and external parasite control cost M5.50-6.80 each for seven of the farmers. An outbreak of fowl pox in the vicinity of one flock required additional treatment and increased the cost to M14.67 for the improved breed. Native birds were also treated and the smaller numbers reduced costs accordingly.

Fixed costs for pens, shelters, feeders, and waterers were approximately M30.00 when buildings and pens were depreciated over 10 years and the feeders and waterers over 5. No costs for labor were included.

The manure produced is a valuable fertilizer and its value was calculated on the basis of nitrogen, phosphorus, and potassium levels reported in the literature. Each flock of improved birds produced fertilizer worth M55-70 during the trial period.

This preliminary analysis of the trial results (the data have just been summarized and a thorough review and analysis have not yet been done) indicates that it is feasible for farmers to keep a small flock of laying hens from a managerial and technical standpoint. The better poultrywomen produced eggs for about M 1.12/dozen when total costs were considered so the economics appear favorable if certain difficulties of obtaining inputs can be overcome. The most difficult problem farmers have in maintaining small flocks of chickens is to obtain feed. Because of regulations, local stores can not sell feed, and the long distances to authorized feed outlets severely limit many farmers. Egg sales were good in the villages, with most sold at the cooperators' homes. There is apparently a demand in rural areas for eggs that is not being met by the official marketing system.

The executive summary of this section is on pages 70-73. The summary of accomplishments and recommendations is on page 98.

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I. Marketing

1. Introduction

Marketing agricultural products involves procurement, storage, resale, processing, and transportation. Marketing inputs for agricultural production involves similar activities, with a major emphasis on distribution through progressively dispersed input retailers to even more dispersed individual producers. The marketing system is facilitated by financing, market information, standards and grades, and risk taking on the part of private entrepreneurs, cooperatives, parastatals, or government marketing bodies.

These marketing functions take place within the framework of the existing infrastructure, institutions, laws and policies, which change over time.

Eckert et al. (1982) describe the characteristics of agricultural marketing in Lesotho and the setting within which agricultural marketing must develop:

"Limited Commercial Production. A major part of Lesotho's agricultural production is for subsistence. Most farmers produce only small surpluses and much of this is marketed informally to consumers within their own village or in nearby villages. Very few farmers produced significant surpluses for marketing through formal channels. The number of market-oriented farmers is typically limited to perhaps 25-30%. Less than 10% of the grain and pulses are marketed through commercial channels.

"Remoteness. Much of Lesotho's agriculture is remote from market centers with at best very poor roads. Many areas are not accessable by road and have no telephone or radio communication services.

"Production Variability. Production varies significantly from year to year suggesting the market must be flexible and able to operate efficiently with a variable level of commodity flows.

"Price Determination in RSA. Because of Lesotho's extensive trade with RSA in nearly all commodities and inputs, and the size of South Africa's economy relative to Lesotho's, most price levels for inputs, outputs, and food will be determined on South Africa-based conditions. Lesotho has little latitude for modifying domestic price relationships. Agricultural commodity and input prices are highly regulated in South Africa which gives some price stability. This has both positive and negative aspects for Lesotho farmers: they may not benefit greatly from higher prices when production is short nor may they realize lower prices for a bumper crop.

"Institutional Variations. Agricultural marketing in the last decade has undergone rapid institutional change. Many new organizations have arisen, often with more than one ministry sharing responsibilities for operation. Major responsibilities and functions

had been transferred from agency to agency. With marketing institutions in a state of continuous change, policies were sometimes conflicting or unclear. By 1981 the marketing economists were given broad duties to analyze the agricultural marketing systems and marketing policies, to determine and describe the workings of marketing systems for inputs, crops, and livestock and livestock products, and to diagnose problems and inefficiencies in the marketing system and make recommendations for improvements."

During the course of FSRP there were three marketing specialists:

Emer E. Broadbent--July 1979 to January 1980
Peter W. Wyeth--August 1980 to March 1984
Ray F. Brokken--July 1984 to June 1986.

2. July 1979 to January 1980

a. Wool and Mohair Marketing

Dr. Broadbent's tour was cut short by a sudden serious illness, but he analyzed wool and mohair marketing in the Transkei, and concluded that the Transkei system worked well and could be duplicated in Lesotho. He made a field trip, the purposes of which were to:

- Accumulate 1978-79 wool and mohair pricing and volume data for various Lesotho livestock producing regions.
- Obtain detailed information on marketing programs and policies designed to improve the Lesotho wool and mohair industry.
- Interview BKB (Farmer Cooperative Brokers), SAWB (South African Wool Board), and SAMB (South African Meat Board) management to discuss development and improvement programs for Lesotho products.
- Obtain and evaluate substantiating data from confidential records to assist in suggesting developmental marketing programs for Lesotho's industry.
- Attempt to determine ways to improve coordination in the wool and mohair marketing system.

Broadbent reported that the leadership of the South African wool and mohair boards indicated they would develop a market analysis and service program for Lesotho upon request of the appropriate Lesotho government officials. If the Lesotho government wanted to establish wool and mohair typing training programs, the BKB, SAWB, and SAMB were willing to train workers to bulk, type, and classify wool and mohair. Siting suggestions would be made for suitable stores facilities, tariff rates would be suggested for all shippers from the local shearing sheds to the typing and stores facilities. They would continue the cooperative pricing program, and jointly evaluate and

suggest all prices to be paid for different types of wool and mohair as well as continue to be brokers to market Lesotho's graded products on the world market.

It was suggested that the Lesotho government begin more intensive control to market Lesotho hides and skins. This added program could provide greater returns to Lesotho's livestock industries.

Some wool production data and prices are shown in Tables III-I-1 through III-I-6. Broadbent concluded that the wool and mohair development that the South Africans did in the Thanskei could be duplicated in Lesotho.

3. July 1980 to March 1984

a. Bibliography on Agricultural Marketing

All members of the FSRP team were asked to write literature reviews. There had been a good deal written about government marketing agencies, but very little had been written on farm level

Table III-I-1. Estimated wool production handled and value of the wool clip[1] by Lesotho districts, 1978/79.

Districts	Wool marketed (kg)[2] Associations	Traders	Total (kg)	Average price (cents/kg)[3]
Maseru	282,832	210,763	493,595	107
Quthing	233,704	174,156	407,860	112
Mokhotlong	233,412	165,487	399,899	121
Mohale's Hoek	142,122	105,909	248,031	99
Mafeteng	130,506	97,253	227,759	95
Qachas Nek	122,649	91,398	214,049	98
Leribe	97,855	72,922	170,777	105
Butha Buthe	83,907	62,528	146,435	111
Berea	81,894	61,027	142,921	85
Total	1,399,881	1,043,192	2,443,073	--
Percent	57.3	42.7	100.0	107

1. Information supplied by BKB differs from the MOA Planning Unit data.

2. Estimates for traders assumed that associations volume represented 57.3% of the clip. Traders volume was a residual. Note: the kg weights of bags of wool are not included.

3. Gross market realization Jul-Jun 1978-79.

markets, hence one research target was to fill this gap. By now this bibliography is outdated (Wyeth, 1981, RD-B-4).

b. Input Distribution

In 1981 Coop Lesotho took over a selected number of stores from the Produce Marketing Corporation (PMC), which was abolished by Parliament that year, and from the Basic Agricultural Services Project

Table III-I-2. Bales of wool marketed by districts, 1974/75-1978/79.

District	1974/75	1975/76	1976/77	1977/78	1978/79
Berea	621	1205	897	811	930
B/Buthe	5154	2689	2808	3024	2848
Leribe	3810	2316	626	706	892
Mafeteng	811	491	4640	4929	4237
Maseru	1066	1403	4262	4094	3805
M/Hoek	1629	1280	557	709	606
Mokhotlong	306	342	769	601	1590
Q/Nek	1494	2100	1790	1527	1936
Quthing	1642	485	1246	1431	1345
Total	16533	12311	17595	17832	18189

Source: South African Wool Board Statistical Analysis of Wool Clip, 1974/75-1978/79.

Table III-I-3. Grease mass (kg) of wool sold by districts, 1974/75-1978/79.

District	1974/75	1975/76	1976/77	1977/78	1978/79
Berea	83,292	168,788	119,178	105,377	120,276
B/Buthe	717,901	368,423	46,520	434,498	397,117
Leribe	556,810	312,886	87,665	101,715	123,353
Mafeteng	111,503	65,285	609,638	629,541	553,325
Maseru	148,546	190,610	566,731	554,652	510,503
M/Hoek	241,565	185,615	72,620	93,691	82,583
Mokhotlong	45,775	49,067	106,388	81,138	216,687
Q/Nek	230,404	331,328	242,811	209,446	269,309
Quthing	256,256	73,506	160,091	181,963	169,146
Total	2,392,052	1,745,408	2,381,642	2,391,921	2,444,299

Source: South African Wool Board Statistical Analysis of Wool Clip, 1974/75-1978/79.

(BASP), a government of Lesotho and multidonor project. There was some debate about the adequacy of input distribution, the number of stores that should be kept up, and the pricing of inputs, especially fertilizer.

Table III-I-4. Average value (cents/kg) of wool sold from each district, 1974/75-1978/79.

District	1974/75	1975/76	1976/77	1977/78	1978/79
Berea	59.31	97.67	105.92	120.39	142.95
B/Buthe	66.37	100.14	108.56	121.72	144.03
Leribe	65.45	101.17	101.50	110.24	135.27
Mafeteng	62.07	95.28	112.94	124.63	149.63
Maseru	71.33	104.99	105.34	121.60	146.76
M/Hoek	59.29	92.33	100.65	119.52	138.28
Mokhotlong	58.83	91.35	115.99	130.57	147.28
Q/Nek	65.31	95.07	105.45	117.20	137.30
Quthing	65.89	101.84	118.45	128.14	152.75
Average	65.01	98.47	108.96	122.22	145.33

Source: South African Wool Board Statistical Analysis of Wool Clip, 1974/75-1978/79.

Table III-I-5. Realization value (rand) of wool sold by district, 1974/75-1978/79.

District	1974/75	1975/76	1976/77	1977/78	1978/79
Berea	49,401	164,852	126,236	126,860	171,929
B/Buthe	476,486	368,952	452,188	528,933	571,967
Leribe	364,421	316,551	88,982	112,131	166,859
Mafeteng	69,207	62,204	688,507	784,610	827,939
Maseru	105,961	200,129	596,969	674,453	752,149
M/Hoek	143,222	171,385	73,090	111,977	114,198
Mokhotlong	26,931	44,821	123,403	105,940	319,144
Q/Nek	150,486	314,994	256,051	245,262	369,750
Quthing	168,840	74,856	189,623	233,044	258,278
Total	1,554,955	1,718,744	2,595,049	2,923,330	3,552,313

Source: South African Wool Board Statistical Analysis of Wool Clip, 1974/75-1978/79.

The purpose of this report (Wyeth, RD-R-4) was to make suggestions about pricing (which were adopted, although not necessarily because of this paper), and about how input distribution might be extended beyond Coop Lesotho's stores. The latter involve truck deliveries of inputs by Coop Lesotho to remote areas beyond it's stores, and a role for private traders. At the time Wyeth believed control of private traders' prices might be feasible under certain circumstances, but became less optimistic and emphasized instead that Coop Lesotho should compete with private traders to inhibit extortionist prices.

c. Input and Crop Marketing for Block I, (the Leribe/Buthe Butha region of Lesotho).

A very large survey was conducted by the Basic Agricultural Services Project (BASP). Part of it covered the purchase of inputs and the sale of crops by farmers. Wyeth analyzed the data about markets at the farm level (Steele et al., 1982, RD-B-5).

The analysis showed that there were very few crop sales. According to the farmers, this was due to low production rather than any problems making sales or obtaining adequate prices. When considering the purchase of inputs, farmers were most concerned about lack of money and access. Recommendations to provide credit and better access to credit follow from these findings, but the paper warns that both problems may be due to a perception by farmers that the costs of buying and transporting inputs are high relative to the

Table III-I-6. Percent yield of wool sold from each district, 1974/75-1978/79.

	Percent average yield				
District	1974/75	1975/76	1976/77	1977/78	1978/79
Berea	39.03	41.66	40.76	41.55	43.34
B/Buthe	41.30	41.93	41.09	41.06	43.30
Leribe	40.50	41.83	39.56	39.81	42.11
Mafeteng	39.98	40.46	42.02	42.21	44.74
Maseru	42.81	43.02	41.15	41.84	44.79
M/Hoek	37.95	39.64	39.70	40.81	41.79
Mokhotlong	39.29	39.63	42.76	43.76	44.11
Q/Nek	40.14	40.23	40.46	40.98	42.20
Quthing	39.26	42.30	43.37	42.99	45.31
% Average	40.36	41.34	41.39	41.72	43.92

Source: South African Wool Board Statistical Analysis of Wool Clip, 1974/75-1978/79.

benefits they can expect from increased yields. If so, and they are correct, they should not be buying any more inputs than they do because the benefits are low. But if they are incorrect, and the true benefits are high, then better information from research and through extension about the benefits is the remedy.

d. Impact of Marketing on Production

This was a cooperative project of the Marketing Section of the Research Divison and the Planning Division that was requested by the Minister of Agriculture to examine the production trends in food grains and, if downward tendencies were discovered, to determine if they were attributable to marketing difficulties of any kind. Areas planted to crops were examined as an indication of production trends intended by farmers. Considerable year-to-year variations were found, with possible downward trends in peas, beans, and wheat. Explanations other than marketing difficulties were considered, including the rapid growth in mine wages, which was thought to have reduced the incentive to produce crops (Wyeth, 1983, RD-B-26).

Under the heading of marketing difficulties, inappropriate producer prices and an inadequate number of sales outlets might have had some depressing effect on intended production, especially peas and beans, because larger proportions of these crops have been sold commercially. Setting prices according to import or export parity (depending on the crop) was suggested to avoid problems stemming from inappropriate prices. To ensure that farmers would be able to sell their crops, private traders could be allowed to act as commission agents for Coop Lesotho, or trade in food grains in their own right.

e. Fruit and Vegetable Marketing

The objective of this project was to gauge the potential to replace fresh vegetables and fruit imports with local production, and to uncover marketing constraints which would discourage farmers from producing (Wyeth and Moletsane, 1983a, RD-B-27). Country wide estimates were made of the volume and seasonality of imports, local production, and self-sufficiency. The most important items were cabbages, potatoes, tomatoes, and onions. A significant potential exists to increase production for import replacement. However, it is constrained by considerable summer production, and by higher winter production costs. Unfortunately, competitive growing areas in South Africa are frost free. Prices indicated a fair amount of competition which benefits consumers. More research needs to be done on prices received by farmers.

Two problems identified among small farmers were a lack of familiarity with the nature of the market and its requirements, and a transportation shortage to move produce when it is ready for sale. As one remedy for the former, it was recommended that daily market information be broadcast over the radio to farmers. As another, a central market could be constructed in Maseru, and possibly other district towns. Alternative types of market were evaluated. In the

most promising, small farmers would have the choice of selling their produce either directly to consumers, or to licenced traders who would sell to consumers from stalls on the premises. Continued use of the import permit system would help limit competition when local supplies were available. Transportation is a much more difficult problem to solve, and depends on what form government assistance to producers, if any, takes in the future. Under present circumstances, loans to farmers to buy pick-up trucks should be investigated.

The summary of this publication was issued as a separate document, RD-B-27A (Wyeth and Moletsane, 1983b).

f. Mohair Trends in Production and Quality

This paper was stimulated by the observation that complaints have been made for at least 50 years about declines in the quality of Lesotho mohair and the average yield per goat, in spite of exhortations to farmers to improve their goat husbandry (Wyeth et al., 1983, RD-B-25).

Available data do indicate a downward trend in quality in recent years. Average yield per goat is far below potential, but this seems always to have been the case. The reason why farmers do not respond to calls for improvements is that it does not pay them to do so as long as they graze their animals on communal rangeland. Hence, while mohair has good income potential for farmers, it will not be realized until grazing on the range is brought under control, probably through farmers' associations of one kind or another.

This paper was presented at the Third Annual Farming Systems Symposium held at Kansas State University, Manhattan, Kansas, in November 1983.

g. Pricing Food Grains

Food grain pricing was one of the first topics to which Wyeth devoted attention after arriving in Lesotho. A number of marketing problems had arisen when prices were out of line with those in South Africa. Several papers of varying length were written around this topic, often in collaboration with Dr. D. Bostwick of the Planning Division. This paper is the culmination of these (Wyeth and Moletsane, 1984a, RD-B-31).

First, the cost-plus and import/export parity approaches to pricing were described and evaluated. The conclusion is that parity pricing will avoid market problems, and although cost-plus pricing will guarantee farmers with average production costs a rate of return, parity pricing will not. However, the variability of average rates of return will encourage farmers to grow those crops for which their local growing conditions are most suitable.

The latter part of the paper considers the relative profitability of the five staple crops under parity pricing. It also illustrates

the different production patterns that could occur under cost-plus and parity pricing and the impact on agricultural self-sufficiency. While cost-plus pricing is more effective at promoting self-sufficiency in each crop individually, parity pricing reduces the overall trade deficit, because surpluses of beans and peas are exported to cover part of the cost of importing maize and wheat.

h. Farm Level Markets

This paper (Wyeth and Moletsane, 1984b, RD-B-32) supplements RD-B-5, Input and Crop Marketing in Block I, summarized above. It uses three other sets of data: the 1981 Baseline Survey in the three Research Division prototype areas; crop disposal and meal/flour purchasing forms employed in a farm records program, organized by the Farm Management Section of the Research Division in the same prototype areas; and crop disposal questionnaires administered as part of the farm management monitoring survey maintained by R.J.G. Steele and T. Ncholu in Leribe and Butha-Buthe.

According to the Baseline Survey data, problems that farmers encountered when thinking of buying inputs are similar to those obtained from the earlier study in the Leribe/Butha-Buthe area with BASP. The data on crops offer additional information about sources and quantities of grain, meal, and flour acquired by farmers, and about proportions consumed, sold, or used in other ways. All three sources show small numbers and amounts of grain sales and wide price difference. However, farmers did not complain that sales were difficult to make. Most were to neighbors at prices above official levels. The BASP study supports the idea that sales are meager because production is low rather than because marketing is problematic. Nevertheless, markets should be monitored and improved where necessary because, as development proceeds, output should grow beyond the absorption capacity of local markets. Commercial channels must performs well to prevent marketing bottlenecks.

i. Other Activities

- In the winter of 1981, an M.Sc. student from the University of Reading in England, David Crush, conducted a study on credit use in one prototype area. Wyeth and the farm management economist assisted him with his work.

- In January 1982 he responded to a request from the Ministry of Agriculture for a brief note on the status of egg marketing in the country.

- In February 1983 Wyeth and N. Moletsane wrote a memo for the Director of Research on the potential to substitute locally produced commodities for maize grits and malt imported by the new brewery.

- In early 1983 the Marketing Section worked with the Statistics Section of the Ministry's Planning Division to draw up forms for the regular collection of data from marketing agencies and private traders.

- When trials in farmers fields were planned for the 1983-84 growing season, the Agronomy and Farm Management Sections decided that it would be most appropriate if the Marketing Section purchased and organized the distribution of all the inputs: 23.7 t worth M8,718. A memo was written on the lessons learned.

- From time to time the Marketing Section participated in discussions, called by the Marketing Section of the Planning Division, which led to the recommendation of producer prices for food grains.

4. July 1984 to March 1986

Dr. Brokken joined the project in July, 1984. Miss Nyakallo Moletsane returned to the Marketing Section as a research officer in August 1984 after attending a course in grain marketing in Manhattan, Kansas. Mrs. Mabaitsi M. Motsamai rejoined the Marketing Section as its Head in October 1984. Three research projects were undertaken during this period: marketing hides and skins in Lesotho, a farmer-level extension program on vegetable marketing, and analysis of livestock production, marketing, and slaughter in Lesotho.

a. Marketing Hides and Skins in Lesotho

The concern about more effective utilization of hide and skin resources of Lesotho dates back at least 50 years. The Marketing Section proposed doing something about this problem at the Mountain Livestock Development Conference, held at Mazenod in July 1984. The conference recommended that the Marketing Section develop educational material on proper flaying of hides and skins.

Table III-I-7. Hides and skins marketed through LPMS, 1984.

	Hides	Skins
Number marketed	38	3272
Total weight (kg)	293	6019
Total value (M)	416	4131
Weight per hide or skin (kg)	7.7	1.84
Value per kg (M/kg)	1.52	0.686
Maloti per hide or skin	10.93	1.26

Source: Livestock Products Marketing Service.

(1) Potential Value

The perentage of hides and skins that are recovered is not known. Those that were collected were very low quality. Estimates on the number collected range from 10-50%. LPMS (Livestock Products Marketing Service) has responsibility to collect hides and skins. In 1984 they collected 38 hides and 3,272 skins (Table III-I-7).

Private traders also collect hides and skins from farmers and butchers in Lesotho. In the past 9 months, two Lesotho buyers have become quite active in collecting from the butcheries, but collection from farmers is still poorly organized.

Data on farmer marketing of hides and skins, the methods of curing, to whom marketed, and prices received were collected in the survey of livestock production, marketing, and slaughter in Lesotho, but are not yet summarized (Table III-I-8).

It should be noted that the majority of the potential hides and skins would come from fallen animals. Hides and skins from fallen

Table III-I-8. Total number of animals and number died and butchered, 1983.

	Cattle	Sheep	Goats	Horses & donkeys
Total	529,175	1,286,975	856,900	230,400
Died	63,125 (11.9)[1]	136,800 (10.7)	66,657 (7.8)	17,125 (7.4)
Butchered				
Households	17,500 (3.3)	80,000 (6.3)	37,175 (4.3)	525 (0.2)
Butcheries	5,166 (1.0)	53,145 (4.2)	878 (0.1)	
Total died and butchered	85,791 (16.2)	270,745 (21.1)	104,710 (12.2)	17,650 (7.7)
Died as a percent of died and butchered	76.3	50.5	63.7	97.0

1. Numbers in parentheses are percent of total animals.

Source: Bureau of Statistics.

animals are worth up to two-thirds the value of hides and skins taken from slaughtered animals if taken from the animal soon after death and carefully preserved.

There are three main practical methods of curing hides and skins: wet salting, dry salting, and sun or shade drying. Dry salting is the

Table III-I-9. Examples of the value of hides by type of curing and grade at a Maseru hide and skin market.

Type of curing	1st grade	2nd grade	3rd grade
Dry salted:			
Weight (kg)	20	20	20
Price (Maloti/kg)	M1.70	M1.55	M0.85
Value (Maloti)	M34.00	M31.00	M17.00
Shade or sun dried:			
Weight (kg)	--[1]	11	11
Price (Maloti/kg)		M0.75	M0.65
Value (Maloti)		M8.25	M7.15

Source: Basotho Tannery, February 1986

1. No 1st grade shade-or sun-dried hides have been received.

Table III-I-10. Estimated potential receipts from sheep and goat skins.

	Average price (Maluti)	Percentage recovered				
		50	60	70	80	90
Sheep						
Slaughtered	4.00	268	321	375	429	482
Fallen	2.80	192	230	268	306	344
Total	3.40	460	551	643	735	826
Goats						
Slaughtered	3.00	57	68	80	91	103
Fallen	1.50	50	60	70	80	90
Total	2.04	107	128	150	171	193
Total skins		567	679	793	906	1,019

method recommended for Basotho farmers. The advantage of dry salting can be seen in Table III-I-9. The hides are down-graded for damage, most of which is incurred by poor flaying or curing.

The potential value of Lesotho hide and skin resources could be around M1 million for skins and more than M2 million for hides, assuming 90% recovery from both slaughtered and fallen (Tables III-I-10 and III-I-11).

(2) Educational Materials

A slide/tape program and a video program on the proper flaying and curing of hides and skins were produced. Also, an illustrated extension handbook entitled "Proper Methods for Flaying and Curing Hides and Skins" was published in both English and Sesotho. A grant for technical assistance from SARCCUS (Southern African Regional Commission for Conservation and Utilization of the Soil) covered the cost of filming and the technical assistance from the Information Division, South African Department of Agriculture. The Instructional Materials Resource Center (IMRC), a USAID-funded project, provided technical assistance and equipment for the video program at no charge to FSRP or the Ministry of Agriculture.

Information on proper flaying and curing was supplied by the Leather Industries Research Institute, Rhodes University, Grahamstown, South Africa, and from the BKB (Farmer Cooperative Brokers) of Port Elizabeth. The script was developed prior to filming, with assistance

Table III-I-11. Estimated total receipts from cattle by percent recovered and by percent by sun drying, dry salting, and wet salting.

Percent cured by			Av. Price[1]	Total % cured & marketed[2]			
Sun dried	Dry salted	Wet salted	per hide (Maloti)	60	70	80	90
				('000 Maloti)			
70	20	10	11.95	515	718	820	888
40	40	20	17.40	896	1.045	1.194	1.343
20	40	40	23.30	1.199	1.399	1.599	1.799
10	40	50	26.25	1.351	1.576	1.802	2.027
10	20	70	29.65	1.526	1.781	2.035	2.289

1. Assumes 76% fallen not bled (Table III-I-8) and 24% slaughtered. Hides are of average quality; weight of animal from which hide was taken is 365 kg. This implies the following prices per skin: Wet salted, M36.00; dry salted, M19.00; and shade/sun dried, M.6.50.

2. From Table III-I-8. Total of cattle died and butchered is 85,000.

from the Information Division, South African Department of Agriculture; African Hides Trading Co. of Port Elizabeth; Lesotho Ministry of Agriculture; and from IMRC. Participants provided their own funding for this meeting. The programs have been shown in each of the prototype areas. Audiences have been most attentive and interested. A follow-up is planned to see if farmers are adopting the suggested procedures.

(3) Training School for Grading Hides and Skins

The Marketing Section organized a 1-week training school in grading hides and skins for livestock extension specialists during the last week of November 1985. The District Livestock Officer and the District Livestock Assistant from nine of the 10 districts attended this short course. The BKB in Port Elizabeth provided two teachers to conduct a 4½-day training program with lectures and hands-on grading exercises. Much longer training is required for grader certification, but the short course fully aquainted trainees with principles and factors involved in grading. The instructors want to adopt the slide/tape program on proper flaying and curing of hides and skins for their short course on grading.

(4) Workshop on Improving Hides and Skins Marketing

The Marketing Section organized a workshop 5-6 May 1986 on improving the marketing of hides and skins in Lesotho. The purpose was to generate ideas about how to improve the efficiency of hides and skins marketing in Lesotho. This included increasing the number of hides and skins collected, and increasing the collection efficiency. Emphasis was on farmer and butcher hides and skins. The following organizations were invited to provide speakers:

- Marketing Section (Research Division)
- Livestock Products Marketing Service
- Lesotho National Development Corporation
- National Abattoir and Feedlot Complex
- Basotho Tanning
- Lesotho Hides and Skins Brokers
- Farmer Cooperative Brokers
- G. H. Hackman and Company, Durban
- African Hide Trading Company, Port Elizabeth

In addition, other organizations were invited to attend or send representatives: Director of Research and Specialist Services, Director of Field Services, Planning Division, Livestock Division, Range Division, Range Division, Agricultural Informantion Services, USAID, ISAS, UNDP, FAO, and EEC.

b. Farmer Level Extension Program In Vegetable Marketing

This project is headed by Miss Nyakallo Molitsane. The project began in response to a request from farmers in the Nyakosoba prototype area for help to market a bumper vegetable crop.

This was apparently the first time they had encountered a surplus so large that it had to be marketed outside their village area. They had little understanding of potential market outlets, how to arrange transportation, and what prices to expect. They did not understand the cost and services involved in the formal marketing system, and argued that they should receive the same prices for their vegetables as they would pay for them in the local store. They were sure that the prices being offered were unfair and insisted that they would let the vegetables rot in the field if they were not paid the local retail prices for them.

Mrs. Motsamai and Miss Moletsane did an outstanding job of showing the farmers their options and explaining the reality of their situation. At the same time the borders were closed to certain vegetable imports which improved prices remarkably. A paper titled "Report on Marketing Vegetables at Nyakosoba Prototype Area" was written at the conclusion of this activity.

It was obvious that if the farmers were to continue to produce significant seasonal surpluses, they needed to learn more about marketing. Therefore the Marketing Section developed a program to teach vegetable producers about marketing. This program is being conducted in the three prototype areas now. The six essential features of the program are to:

- Provide information to farmers on price variability by commodity, by season, and by different quality grades.

- Aquaint farmers with the possible uses of this information to plan what vegetables to plant and when to plant them.

- Provide information on what farmers can do to enhance and maintain quality during both production and marketing.

- Aquaint farmers with alternative market outlets for their produce. These include their own roadside or nearby town vending stands, selling outside to hospitals or schools, selling directly to retailers such as cafes, supermarkets, other street venders, and selling to wholesalers.

- Field trips are planned to take vegetable producers from the Nyakosoba and Siloe prototype areas to nearby towns to see first-hand some of the alternative markets for their vegetables. Reports on these field trips are forthcoming.

- Finally, farmers will be aquainted with the steps they must take to arrange timely and reliable transportation for their vegetables.

An extension pamphlet on farmer marketing activities, including planning and measures to improve and protect product quality is currently in draft stage. In addition, a survey of all vegetable producers in each prototype area was conducted. A follow-up survey includes marking and measuring each vegetable plot. The follow-up sample includes all large producers and 25% of the smaller producers.

The data are currently being prepared for computer summary and analysis.

c. Analysis of Livestock Production Marketing and Slaughter in Lesotho

This is a joint project with cooperation and funding from four major sources:

- Washington State University, Farming Systems Research Project, funded by USAID;
- University of Saskatchewan and Institute for Southern African Studies at the National University of Lesotho, funded by the Canadian Internation Development Research Centre;
- The Research Division of the Lesotho Ministry of Agriculture, funded by the Government of Lesotho; and
- A research grant of $10,000 from SACCAR (Southern African Center for Cooperation in Agricultural Research), funded by the SAEC (Swedish Agency for Research Cooperation with Developing Countries).

Mrs. Mabaitsi Matsamai is the principal investigator of this project. Research advisors are Brent M. Swallow, research fellow, Institute for Southern African Studies, National University of Lesotho, and research associate, University of Saskatchewan; and Dr. Ray F. Brokken, marketing economist, Farming Systems Research Project, Washington State University.

Swallow led the development of the justification and objectives for this analysis and survey questionnaire, and is senior author on these manuscripts.

The survey was administered to 450 livestock-owning households throughout Lesotho. The households were randomly-selected from a list of livestock owners in each of the 18 randomly selected population census enumeration areas (EAs). The 18 EAs were selected randomly subject to the constraint that an equal number of EAs be selected from each of the geoclimatic zones. The zones are northern lowlands, southern lowlands, foothills, remote mountain, less remote mountain, and Senqu River valley. The survey was conducted during the winter, July-Sep 1985.

Mrs. Motsamai supervised 12-14 field enumerators who administered a 56-page questionnaire to 540 respondents. There were no rejections. Data entry is still underway. Analysis of the data is expected to extend beyond the end of the project. Results will be included in Vol. II of this report.

(1) Development of Livestock Survey Questionnaire

This paper discusses the background, objectives, and special considerations needed for an analysis of livestock production, marketing, and slaughter in Lesotho. Its purpose is to provide guidelines for the development of a questionnaire to collect data for the proposed analysis. Livestock owners throughout Lesotho will be surveyed to collect necessary information.

Problem. Development of the livestock industry has become a major government priority in recent years. For Lesotho to tap its range, environmental, and human resources more effectively, three developments are seen as essential. First, the overcrowded range must be destocked. Second, breeding, management, and grazing practices must be improved. Third, marketing channels must be made efficient and attractive to stockowners. Successful fulfillment of these three developments has been the objective of initiatives to:

- construct a more secure marketing infrastructure;
- implement experimental grazing associations; and
- provide an extension education program on production information and improved breeds.

However, the consequences of these initiatives cannot be quantified because of the limited basic information about livestock production and the decision environments of Basotho stockholders. Furthermore, proper incentive stuctures, extension activities, and government policies are stymied by this lack of information and understanding.

Objectives. The overall objective is to provide public and private decision makers in Lesotho with economic insights critical to the development of the Lesotho livestock industry. A number of subobjectives are summarized in this section.

- Evaluate the total contributions of Lesotho's cattle, sheep, and goat populations to the domestic economy. Total value is the values of stock (meat, offal, hides, and skins), flow (milk, draft, dung, progeny, wool, and mohair), financial (savings, liquidity, store of wealth), sociological (mafisa, bohali), and psychological (prestige, status) products of livestock. Values of these products are likely to vary, and therefore must be evaluated seperately, with the type of farming system and the economic and demographic characteristics of the farm manager and his family.

- Determine the economic, biological, and sociological variables key to the decision making of the Basotho stockholder and likely responses to changes in those variables.

- Examine the importance of animal draft power in: (1) the stock-holding behavior of the Basotho; and (2) making meaningful offtake comparisons and analysis. Interrelationships of cattle and crops are likely to vary with the type of farming system and the availability of draft animals.

- Examine the utilization patterns of animals dying from natural causes. An understanding of the value of a fallen animals is critical in Lesotho where most animals leave the range due to death by natural causes. Taking account of the utilization of fallen animals is also important in calculating meaningful offtake rates.

- Determine the importance of livestock as financial assets. If cattle, sheep, and goats confer utility as exchange and savings mechanisms, then they can be compared to alternative mechanisms with respect to riskiness, rate of return, and liquidity.

- Examine interrelationships between land tenure, labor, capital, and organizational constraints and their effects on stock-holding behavior. The Lesotho land tenure system is often cited as the major factor affecting the stocking rate and the perceived overstocking. Studies conducted elsewhere in Africa raise some question of the persuasiveness of the tenure factor. Labor, capital, and organizational constraints have been cited as offsetting factors to the communal tenure system.

- Examine both formal and informal markets for livestock and livestock products.

- Prescribe policies appropriate to meeting development objectives in the livestock sector.

Essential to meeting these specific objectives is the development of conceptual models of Basotho stockmen decision making. The factors affecting the production, marketing, and stockholding of cattle, sheep, and goats must be determined and modeled in a conceptual framework that will permit empirical evaluation of their relative importance. Products which must be valued are meat, progeny, hides and skins, wool and mohair, dung, draft power, store of wealth, prestige, bohali, and other social and cultural utilities.

Estimated Impact. Destocking Lesotho's rangelands is a policy developed as a means to improve livestock and range productivity and to secure range conservation. The development of secure infrastructure has also been undertaken to facilitate livestock marketing. However, appropriate incentive structures, extension activities, and government policies to encourage stockholders to market their livestock through commercial channels require further development and implementation. Policies have been slow to develop because of the lack of understanding of the decision framework of the Basotho stockmen. While a number of propositions have been stated regarding the importance of certain economic, biological, and

sociological factors, no comprehensive study verifying these propositions has been carried out to date. Appropriate government policies on pricing, extension, and land tenure will be prescribed. These will help the government of Lesotho meet its goals of commercialization and destocking. An important contribution to understanding livestock systems in Lesotho and broader implications for all of sub-Saharan Africa is foreseen.

(2) Livestock Production, Slaughter, and Marketing

The problem statement in the project proposal addresses two major issues in the development of the livestock sector in Lesotho: (1) the institution of appropriate government policies, and (2) the development of a secure marketing infrastructure. The survey analysis will provide data for a discussion of the first of these issues. In addition, however, it is well within the context of this study to examine key factors relating to the latter issue, that is, to examine the current formal and informal marketing channels for livestock and livestock products in Lesotho. This information is essential to plan future developments of the marketing channels for both livestock (cattle, sheep, and goats) and their products (meat, hides, skins, wool, and mohair).

There are a number of questions to be addressed to meet these two issues:

<u>The Structure of Lesotho's Rural Livestock Economy</u>.

- What is the real contribution of Lesotho's cattle, sheep, and goat populations to its cash and subsistence economies, by area and by group?
- What is the distribution of livestock wealth among Lesotho's rural population?
- How do livestock compare to other sources of rural income and subsistence in terms of contributing to the rural economy?

<u>Herd Size and Herd Composition</u>.

- Is there a general life cycle of livestock ownership?
- Do livestock owners keep a combination of cattle, sheep, and goats which is most appropriate for their situation from an economic perspective?
- How do herd sizes and herd composition vary with geoclimatic conditions, farming systems, and demographic and economic characteristics of the households?

Investment Behavior of Livestock Owners.

- What proportions of the cash incomes of rural residents are consumed, invested, and saved, and how do these proportions vary?

- How do livestock investments compare to alternative rural investments?

Stockowner Reactions. What is the likely response of different groups of livestock owners to:

- Changed prices of cattle, sheep, goats, milk, meat, wool, mohair, crops, and nonlabor inputs?

- The development of a rural banking system with, and without, higher rates of interest paid on savings accounts?

- Changed input availability, including labor, management, and range inputs?

- Alternative grazing controls, taxes and restrictions?

- Improved productivity?

Herd Management.

- What do livestock owners consider to be the important production constraints, and how do these vary between areas and groups of stockowners?

- What are the constraint levels on management, labor, investment capital, summer range, and winter fodder?

- How do ownership and management perspectives and practices differ for different groups of stockholders:

  --migrant men leaving management to wives?

  --migrant men leaving management to other people?

  --absent owners loaning cattle out on mafisa?

  --male- versus female-headed households?

  --regular herdboys versus owners who also herd?

- What are specific management practices regarding winter and summer grazing, and the production, collection and feeding of fodder?

Social Functions of Livestock.

- Do cattle, sheep or goats generate any positive or negative utility to either the givers or receivers of bohali payments?

- How important is mafisa and what are the reasons for giving or receiving animals under mafisa?

- What is the importance of the three major livestock groups in ceremonies?

Financial Aspects.

- How liquid are cattle, sheep, and goats as financial assets?

- To what extent are livestock held and sold to meet basic and emergency cash requirements?

- Do livestock owners rely on livestock as their sole, primary, or secondary form of investment/savings?

- To what extent are livestock used as exchange mechanisms in rural economies?

- What is the degree of risk involved in livestock versus other available forms of investment?

Attitudes Toward Conservation and the Environment.

- To what extent do livestock owners recognize the problem of overgrazing and range degradation?

- What do livestock owners perceive to be the best solution to the problem?

- What are the attitudes towards alternative solutions?

Design of Marketing Channels. In Lesotho the existing marketing channels for all livestock and livestock products are in the infant stages of development. Further development will require the design and implementation of new institutions and the rationalization of existing institutions and marketing channels. These initiatives will require a substantial information base on current use of formal and informal markets. The following questions will help to frame that required information base:

Major Market Outlets.

- What are the available market outlets for live cattle and what are the quantities marketed through each?

- What are the available market outlets for live sheep and goats?

- What proportions of hides and skins are utilized from slaughtered and fallen animals? How are hides and skins preserved; sun-dried, dry-salted, or wet-salted? How are hide and skin marketed?

- What are the major market outlets for offal?

Major Sources of Supply.

- What are the major sources of supply for live cattle, sheep, and goats?
- What are the major sources of supply of inputs?

Prices.

- What are the average prices received for livestock and livestock products?
- What is the form of payment for livestock and livestock products?
- How are livestock owners' price expectations formed for livestock and livestock products?
- Are prices generally expressed in weight or animal basis?

The Lesotho Problem Situation. The livestock production, marketing, and policy situation in Lesotho has several important and unique components which must be detailed before the model is fully developed. This discussion will necessarily be brief, with only selected features of the livestock sector addressed. For a more thorough report on livestock in Lesotho, readers are referred to Phororo (1979).

The Policy Situation. The Government of Lesotho is actively pursuing two major policies in the livestock sector. The first is to cause a destocking of the range, and the second is to develop the industry by increasing quality standards and developing processing industries.

The Problem of Overgrazing.

In 1981-82 Lesotho's rangeland carried 562,000 cattle, 1,337,000 sheep, 930,000 goats, 103,000 horses, and 97,000 donkeys. Applying an animal unit (AU) definition of 1 AU equal to 1 cow, 1 horse, 5 sheep, 5 goats, or 1.5 donkeys, 1.184 million AU populated the range. Compared to an estimated total carrying capacity of 0.347 million AU, computes to an overstocking of 241% (Range Management Project, Ministry of Agriculture). This estimate of carrying capacity is low compared to other estimates which vary between 0.389 million and 0.634 million. Even with the higher carrying capacity estimate, Lesotho's range is currently 87% overstocked, still a very serious situation.

Overgrazing is a major contributor to the erosion problem in Lesotho. The erosion problem is not a new one in Lesotho. In the 19th century several travelers noted the donga erosion prevalent in the lowlands (Germond, 1967 as cited in Gay, 1984). The problem was first linked to overgrazing in the 1930s (Pim, 1935; Staples and Hudsom, 1936; both as cited in Phororo, 1979). Phororo (1979, p. 149) describes the problem as follows:

"Extensive uncontrolled and careless grazing practices have been applied to the precipitous mountain slopes with eroded soil. The grass cover has been destroyed over vast areas and in many places the soil has been eroded down to bare rock and on most of the mountain slopes there is a dense growth of unpalatable and undesirable shrubs. A picture of utter destruction and devastation of land resources is presented."

Despite the seemingly obvious erosion and overgrazing problem in Lesotho, the Basotho attitudes seem to indicate little awareness and appreciation of the problem. "They want to put as much land as possible into production, they want as many animals as they can manage to keep alive - and they don't see that erosion has anything serious to say to these issues" (Gay, 1984, p. 68).

The Importance of Small Stock in Lesotho.

The statistics in the preceeding section illustrate an important factor in addition to the level of overgrazing in Lesotho: the importance of sheep and goats in the country. Cattle compose 50% of the total AU,, the remainder are largely composed of sheep and goats. This makes Lesotho very unusual within Africa. Of all countries in sub-Saharan Africa, only Mauritania, Somalia, Togo, Liberia, and Gabon have a lower proportion of cattle than Lesotho (Simpson and Evangelou, 1984). Lesotho shares very little in common with any of these countries, geographically, climatically, agriculturally, economically, or socially. The principle products of sheep and goats in Lesotho are wool and mohair. The production and exports were M7.6 million or 73% of the value of all exports from the agricultural sector (Marketing Section, Ministry of Agriculture, DRAFT). The importance of wool and mohair to generate cash from sales must be recognized in any study of livestock in Lesotho.

Phororo represents many other analysts when he discusses the different uses of the categories of livestock in Lesotho.

"Cattle are therefore reared largely for subsistence farming; horses and donkeys for utilitarian purposes. Pigs, poultry and dairy animals and, to a lesser extent, sheep and goats are perceived by farmers as commercial stock."

Tenure and Grazing Lands in Lesotho.

No individual in Lesotho owns land. Rather the land owned by the Basotho nation is held in trust by the King as the Head of State. Traditionally, rights to the use of arable and urban land are granted by local chiefs on behalf of the King. Nonarable land is generally used as grazing land and its access has been open to all Basotho stockowners. The traditional system was based on the concept of access to land for all Basotho. At times of lower population density, the system was a fair and equitable one, presenting little deterrent to development. Because the average size of arable land holdings is reduced to 1.4 ha, and for 20% of all rural households the traditional

system has been judged to be a deterrent to production and investment, the 1979 Land Act was devised to enhance tenure security, to promote productive investment in land holdings, and to stimulate intensified crop agriculture (Mosaase, 1985).

The 1979 Land Act does not apply to rangeland, and its tenure remains communal. Grazing associations and range management projects (such as the projects at Sehlabathebe and Mphaki), have made some attempts to control numbers of animals grazed in relatively small project areas, but in general range access remains open. This communal tenure system has often been postulated as a major contributer to the current overstocking in Lesotho (Range Management Division, 1984) and across Africa (Jarvis, 1980). The "Tragedy of the Commons" (Hardin, 1968) is that communal resources will be overutilized by individuals attempting to maximize their personal gains. Some analysts have argued that land tenure is not as important as is often stated. Stryker (1984) suggested that herder skills and cash-flow constraints offset the communal tenure system. Lawry et al. (1984) argue that some form of communal tenure is often most appropriate from both economic and ecological perspectives.

Cattle as Investment in Lesotho.

The cattle as capital model presented by Jarvis (1974), Arizo-Nino and Shapiro (1984), and the graphic model presented by Jarvis (1984) both raised the importance of the interest rate in determining cattle investment decisions. Two recent papers have picked up this theme and applied it to Lesotho. Fritsch (1984) suggested that:

> "... the lack of suitable alternative investment opportunities during the period of rapid increase in cash income provides a major explanation for the rapid buildup of cattle in the mid-1970's."

Swallow (1985) calculated real prime and savings interest rates and found real prime rate to average -0.07% and real rates on savings to average -11.31 to -9.27% over the 5-year period from the 4th quarter of 1978 to the 4th quarter of 1984. Based on this analysis, Swallow argues:

> "With communal grazing lands and an investment capital cost of zero, cattle will be preferred investment to the point where the value of meat, milk, dung, draught and prestige produced equal the labor and other variable costs. If these costs are very low, as is likely the case in Lesotho, the stocking rate may be pushed very high. An increase in the capital cost can have a large impact on the stocking rate."

The Importance of Oxen as Producers of Traction.

In Lesotho, oxen are the primary source of traction to pull farm implements as well as provide transportation. Since farming is generally mixed, 87% of farm households hold land while 35% hold

livestock, the livestock/crop interrelationships are likely strongly affected by the oxen sector. A previous study has suggested that traction is the most important factor for farmers to keep cattle (Jenness and Khethisa, 1972 as cited in Phororo, 1979, p. 10). The importance of oxen as a source of traction likely varies between mountain and lowland areas.

The Importance of Cows as Producers of Milk.

In some African societies the most important product of female animals is milk. Swift (1975) suggests that in the Kel Adrar society in northern Mali, the most important economic product is milk. Cattle, sheep, and goats are managed to maintain a constant flow of milk throughout the year. In the Arizo-Nino and Shapiro model, milk is shown as being an important flow product of cows in the Sahel. In Lesotho, milk is a potentially important product of cows. A survey by Gay (1977) indicated that literate male stockholders mention the importance of having dairy animals and that good care is essential for dairy production. An informal survey of farmers selling cattle at a recent Sehlabathebe auction indicated that many were selling oxen to raise money to purchase a dairy cow. The higher management and feed input levels required for sustained production from dairy cows may restrict this to better farm managers. A factor suggested to affect the use of cows in milk production is a distrust of the milk from pregnant cows. This may be as much of a biological as a social factor; milking cows generally lose weight, cows are difficult to bring into ovulation when losing weight.

The Importance of Cattle as Dung Producers.

Lesotho is a fuel-poor country. Indigenous forests exist, but occupy a very small proportion of the total land area. Woodlots have been planted, but to date, have generally been small scale and have severely restricted harvests. Given the lack of alternatives, dung has become a very important fuel. Some biogas generators have been established in an attempt to use fuel from dung more efficiently, but most dung continues to be burned after drying. Some preliminary investigation is required to determine the importance of dung as a flow product from cattle production. It may have no effect on the decisions of stockholders, or it may be viewed as a public good, conferring no benefit on the owner of the animal.

The Social Roles of Livestock.

A number of social factors are hypothesized to affect stockholding decisions in Lesotho. Cattle are used to meet brideprice (bohali), they fulfill an income distributional function (mafisa), and they confer prestige, power and status to their owners (Phororo, 1979, p. 15-19).

Bohali. The tradition of bride price is far from unique to Lesotho. In most traditional African societies, bride price was an important cultural phenomena. Quam discusses the payment of

brideprice in the Karimojong society (Uganda) as one of investment in the recruitment of women for the household. Women are important recruitments to the households since they:

> "... provide essential labor in agriculture and more importantly expand the labor force through child-bearing. Economic growth in the household depends upon an expanding labor force. Livestock are attracted to the household grazing unit from other households that have a labor shortage, and gardens are expanded as more hands are available. Polygamy is the marriage pattern that is generated by these transactions in the pursuit of wealth."

In modern Basotho society bohali continues to be paid, but its role cannot be defined in such purely economic terms as Quam uses to describe the Karimojong brideprice. Bohali may have originated for the reasons suggested by Quam, but its continuation to this day is likely based more on custom and tradition than on economics. In more rural areas, bohali is given in almost all marriages and the majority of bohali payments involve livestock. In the Thaba Tseka Project area, 71% of bohali payments involved livestock in 1975 (Jenson, 1976). However, in more accessible areas, money has increasingly replaced livestock in bohali payments. In the Thaba Bosiu Project area, 56% of the bohali payments involved livestock in 1974 (Ministry of Agricuture, 1975).

Anecdotal evidence suggests that the trend is for bohali payments to more often involve cash, and for the absolute value of bohali payments to decrease over time, particularly among more urbanized and educated people. The cash equivalent value of cattle in bohali payments is suggested to be M100 currently, far less than current market prices. This suggests that cattle confer negative utility in bohali payments, or more likely, that the absolute levels of bohali payments are declining at the same time as the use of livestock in bohali is declining.

Young male Basotho miners are often characterized as using their earnings from South Africa to buy cattle, then trek the cattle back to Lesotho. When they have accumulated enough cattle, they may meet the brideprice and find a wife. The assumption is that cattle are the strongly preferred form of brideprice. However, Phororo suggests that increasingly, cash is being substituted for cattle in bohali.

There are two explanations for the use of livestock to meet brideprice. First, livestock are the preferred form of brideprice and confer a valuable utility either to the groom or to the father of the bride. Secondly, livestock are the best of alternative investments. As other investments are becoming important, the use of livestock in meeting bohali will decline.

Livestock may confer a utility or a disultility from their use in bohali. A value may be determined for this utility through experimental analysis.

Mafisa. Mafisa is sharing the uses of livestock. Phororo (1979, p. 16) describes mafisa as being an important component of Basotho society. Traditional Basotho society is one of sharing; cropland users share the use of crop residue with livestock owners, and in return livestock owners share their stock.

Under mafisa, livestock owners give up the use of their animals for blocks of time, usually a full year. The recipient of the loaned animals takes them into his herd, treating them as his own for the period of the mafisa. The recipient bears all the costs of raising the animals and receives all the benefits of ownership, draft power, milk, and progeny. Traditionally, mafisa was seen as generating most of the benefits to the recipient. An owner with extra stock would share one or two animals with someone less fortunate. It appears, however, that the benefits of mafisa may often accrue to the lender, rather than the borrower of the animal. There are large economies of size in livestock herding, a herdboy can herd six animals as easily as one. Farmers with a small number of livestock may find it advantageous to give up all use of their animals. In the Thaba Tseka Project area only 29% of the farmers gave "helping others" as the major reason for giving animals on mafisa, while 50% gave "lack of man-power" as the major reason. Of farmers receiving animals on mafisa, 23% gave "helping others" as the major reason, while 61% gave "gain traction power" as the major reason (Jenson, 1976, pp. 30-31).

Prestige, Power and Status. The African livestock literature is mixed on the topic of the prestige, power, and status value that animals confer on their owners. If these factors are simply viewed as additional utilities to livestock ownership, then they may be indistinguishable from other livestock flow products, such as milk or draught. The challenge is to devise a method to determine the prestige value of different animals. It will be important to determine the factors which contribute to the prestige, such as the number and quality of cattle, horses, donkeys, sheep, and goats, the size and health of oxen, or some contribution of these factors.

Cash Flow Constraints.

Traditional Basotho stockholders did indeed face severe cash flow constraints that limited their investment in productive assets. The extent to which this continues today is an empirical question which deserves serious testing in the current analysis.

The Dependence on South Africa.

The models by Jarvis of Argentina (1974), Doran, et al. of Swaziland (1979), Nolrdblom of the United States (1981), and Ariz-Nino and Shapiro of the Sahel (1984), all considered cattle prices to be determined exogenously. In the case of Swaziland this assumption is realistic, since South Africa dominates the market in Swaziland. However, for the other models the assumption is limiting. A general model of a nation's livestock economy must usually feature endogenously determined prices.

The livestock market of Lesotho, similar to Swaziland, is dominated by the South African market. Cattle in Lesotho are only 1% of the combined cattle inventories of the two countries.. In this situation, not only are prices determined exogenously, but livestock and meat imports and exports play a very important role in the domestic market. Breeding animals are not only recruited from the domestic herd, but can also be imported. There is not likely to be a cattle inventory cycle in Lesotho to compare with that of the United States, or to South Africa, where additions to be breeding inventory must be recruited from within the country inventories. Moreover, a large part of the Lesotho cattle inventory is held for draft power and not just for investment.

Emphasis on the Stockholder.

In the studies reviewed in the previous paper, conceptual discussion was generally focused on the stockholder and his decisions, but the empirical analyses were generally conducted at an aggregate level. Micromodels were supported with macroanalysis. In this study, a micromodel will be developed and tested with both micro and macrodata for these reasons:

- Comparisons with other studies elsewhere in the world will require testing relationships between certain key variables. Most important are the relationships between prices and marketing cattle, and between interest rates and cattle marketings.

- Macrolevel data available in Lesotho is of low quality and is generally of a restricted scope.

- It is the stockholder who makes the decisions regarding livestock production, slaughter, and marketing; it is the stockholder who must change his behavior for policies to have an impact; and thus it is the behavior of stockholders which must be examined.

Analysis of Price Expectations.

The investment models presented by Jarvis and Arizo-Nino suggest that producers interpret price changes to be permanent. These two models deal with individual stockholder behavior. Nordblom's model dealt with aggregate behavior, relating changes in culling and recruitment rates to changes in expected present values for breeding purposes in relation to present slaughter prices. It is noteworthy that many producers, perhaps the majority, maintain a steady course of production and marketing over time, without major inventory adjustments in the face of price changes. Clearly, all producers do not react alike to a given price change. Jarvis does allow that price changes which are expected to be temporary will have different impacts than those which are expected to be permanent, but leaves the discussion at that point. The differential effects of price changes which are expected to be temporary versus permanent suggests the importance of the formation of producer price expectations, or in the distribution among producers in their reactions to changes in prices.

Home Versus Commercial Slaughter.

In neither the Jarvis or Doran et al. (1980) studies was there any discussion of the definition of the slaughter or offtake variables. Slaughter or offtake may refer to levels of aggregation ranging from only commercial sales, commercial plus local sales, commercial plus local sales plus home slaughter, or commercial plus local sales plus home slaughter plus fallen animals. In 1983-84, 1,471 cattle were sold at 14 commercial auctions organized by the Livestock Products Marketing Service. In 1982, 10,171 Lesotho cattle were slaughtered at licensed butcheries (Moteane et al., 1984). In 1981-82, 72,601 cattle were either slaughtered or died in Lesotho (Livestock Division, MOA, 1984). From these numbers it is clear that offtake or slaughter variables are very dependent on definition.

The best data available on livestock sale versus slaughter in Lesotho exists for the Thaba Tseka Project area in 1975. Of 225 cattle either sold or slaughtered, 102 were slaughtered at home. Very little reliable information exists on the use of fallen animals. This could potentially be the most important component of offtake. More analysis is required.

The Importance of Migrant Labor.

Low et al. (1980) found that mine earnings were an important factor affecting cattle offtake in Swaziland. This relationship is consistent with both the capital asset and cash needs models. Such a relationship has also been hypothesized to exist in Lesotho, where migrant labor is much more prevalant. The relationship between migrant income and herd decisions must be further analyzed in Lesotho.

Migrant labor may affect livestock decision-making in an additional way. Many migrant workers own livestock in Lesotho but spend the majority of their time working outside of the country. In this case the responsibility for the management of the herd falls on the other household members, usually the wife. With the investment and management decisions so separated in the household, it is possible that investment decisions are made without consideration of all of the management information. For instance, male cattle owners may not recognize the labor constraints which exist in the household to the extent that the defacto manager, the wife, recognizes them.

The Policy Environment.

The government's policy objectives were stated at the beginning of this chapter as threefold: destocking, quality improvements, and increasing processing of animal products. The development of a secure infrastructure has been undertaken to facilitate cattle marketing. However, appropriate government policies have not been devised to meet the destocking objective. At a recent government-sponsored seminar (MOA 1984), alternative policies were suggested to meet the government's objectives. Policies that were suggested include price incentives, grazing fees, rural banking services, land tenure reform

and extension. The prescription of appropriate policies is intended to be a primary product of this study. The suggested possible policies will be briefly discussed:

- Price Incentives. Bostwick et al. state that "it has been repeatedly asserted that the basic solutions to the problem of livestock marketing are to institute a suitable physical infrastructure, and to provide a price incentive to livestock producters." (MOA, 1984, p. 33).

- Grazing Fees. The appropriateness of grazing fees was discussed at the seminar under the topic of determinants and measurements of overstocking and the development of range management control (p. 4 of Seminar proceedings). No conclusion was reached.

- Rural Banking Incentives and Infrastructure. Fritsch suggests that the payment of higher rates of interest by commercial banks and the development of a more formal banking sector in rural areas is required to encourage destocking. Cattle are the traditional form of investment, and an alternative and better investment must be offered.

- Tenure Policy. The Range Management Division clearly laid much of the blame for the current situation on the communal tenure system. They suggest that of the possible alternative methods to control overgrazing on communal rangelands, the formation of grazing associations is likely the best alternative.

It is against the backdrop of this policy debate that the current study is being conducted. One of the major goals of the study must be to investigate these and other possible policies.

d. Other Activities

A number of other activities involved the Marketing Section including:

- Lectures at the subject matter training schools for extension personnel in each of the 10 districts.

- Representation on the Interministerial Committee for the Lesotho National Abattoir and the Management Committee for the National Feedlot.

- Attendence by Mrs. Motsamai and Dr. Brokken at the joint FAO/ECA Group Consultation on Food Marketing Improvement in Eastern and Southern African countries, held in Arusha, Tanzania 11-14 Nov 1985, to present a paper entitled "Food Marketing in Lesotho" by Ray F. Brokken, Mabaitsi Motsamai, Brent M. Swallow, and Malijeng Mpemi.

- Teaching at Lesotho Agricultural College, Mrs. Motsamai taught a course in micro economics at LAC in the second term of the 1985-86 academic year.

- Attendance at an FAO workshop on Small Farmer Marketing Extension Services by Miss Nyakallo Moletsane, who will present a report on Farmer Level Extension program on Vegetable Marketing in Lesotho that is currently underway.

e. Publications

Papers and reports not published by Research Division in the numbered publications series.

Broadbent, Emer E. "Field Trip Report Regarding Lesotho Wool and Mohair Marketing." September 20 to 30, 1979. Memorandum Nov.15 1979.

Brokken, Ray F. and M. Motsamai. "Proper Methods of Flaying and Curing of Hides and Skins". A farmer Extension Information Pamphlet published in both English and Sesotho (ready for printers now).

Brokken, Ray F., M. Motsamai, Brent Swallow and Malijeng Mpemi. "Food Marketing in Lesotho". Paper prepared for the Joint ECA/FOA Group Consultation TCDC for Food Marketing Improvement in Eastern and Southern African Countries. To be published in a proceeding (in process).

Brokken, Ray F., M. Motsamai, Brent Swallow and Malijeng Mpemi. "Grain and Pulse Marketing in Lesotho". To be published as Research Bulletin (one more revision).

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J. Extension

1. Introduction

Agricultural extension education is that form of nonformal education developed specifically for agriculture. Development strategists now agree that extension education is vital to the crucial problem of rural poverty worldwide.

Farming systems research (FSR) is one strategy that seeks to orient agricultural investigation in such a way that scientists become problem solvers in partnership with poor farmers whose productivity is constrained by factors and situations as they perceive them. By understanding the farming "system", farmers interact with it and scientists contribute to mutually discovered innovations, which have an enhanced probability of being tried and ultimately adopted by the farmers who share in the discovery. It is expected that mutually discovered innovations and technologies generated in partnership with farmers will be more readily accepted by a wider rural population living under similar constraints than will "solutions" handed down by researchers and educators. It is expected that extension educators in developing countries will see the wisdom of the strategy and systematically promote knowledge and skills, generated by FSR, among farming communities.

At every step in the FSR strategy, extension education is critical since farmers are partners in the entire process. Those farmers must be encouraged to share potential solutions to farm problems, which they themselves help discover, through purposeful and proactive extension education dynamics. Extension educators must become part of the FSR strategy intellectually and experientially since extension education is the key to the diffusion of desired change.

It is reasonable to believe that extension education, which has helped generate such phenomenal agricultural advancement in the U.S. and other countries, should then have widespread application in addressing the problems of agriculture in the developing world. That this has not been an easy transition is well known, and the experience over the past decades has produced many models and even more challenges which have become part of extension literature.

There is no stage of FSR in which extension should not be involved (Shaner, 1983). On the contrary, extension inputs are important to target and research area selection in view of extension knowledge of farmer and environmental conditions. Problem identification and the development of a research base are activities which make considerable use of extension expertise. An added advantage is that of integrating extension into FSR while problems and opportunities for research are being articulated. Extension's knowledge of environment, organizations, input situation, markets and sociocultural constraints is helpful to the planning of on-farm

research. That research itself is often assisted by extension personnel, thus augmenting the manpower available for the task. The diffusion of recommendations produced by the FSR process is the province of extension, and is made more effective by having been involved in all previous steps. Shaner (1983), in depicting the extension involvement graphically, sees extension carrying sizeable responsibilities in site selection and problem identification, and performing the major role in multilocational testing and extending recommendations. He concludes that the FSR focus on understanding farmers in their environment, identifying farm problems, and designing and implementing on-farm trials together with farmers, provides the ground for a central and critical extension input.

In summary, extension education is a unique form of nonformal education developed over time as most appropriate for farmers and other rural people. Its evolution in the United States and elsewhere has established inherent elements, principles, and practices which have made it successful in much of the developed world. Among such components are structure, nonformal educational theory, extension methods, linkages, the media, farmer participation, flexibility, adaptability, and institutional support. It is noted that the attempts to transfer the model in its Western form to the developing world have not always been successful, but the T & V (training and visit) system espoused by the World Bank, and the farming systems research/extension model currently sustained by USAID, are touted as contemporary products of new thinking. In combination with research via the FSR/E approach, extension education is a vital element in agricultural development programs.

2. Extension Education Programs

The FSR Project has been a dynamic component of agricultural development in Lesotho since 1979, and extension has played a central role in that involvement. While the work focus of the initially deployed FSR information/communications specialist is manifest in the extensive publication of research circulars and other audio-visual and communications systems (Beckerman, 1981), the more recent FSR extension specialist operated under much wider terms of reference.

The recent extension effort within the context of FSR in Lesotho was expected to provide training and guidance to field extension staff in principles and methods of extension education to facilitate the transfer of research findings to village farmers. It also was to design, test, and monitor alternate methods for involvement of farmers in cooperative agricultural production and management, as well as alternate methods whereby communications could be improved among project staff, field extension staff, and farmers. In so doing, extension was to obtain evaluative feedback from farmers, field extension personnel, and others concerning new farming practices (Bath, 1980).

Further, extension was called on to use approaches compatible with farmers' literary levels and cultural backgrounds. Coordination of technical information delivery to village households and provision of feedback was part of the FSR extension role. Continuing education for extension field workers, subject matter specialists, and other local leadership was expected. Extension was likewise responsible for the publication of research findings.

With specific reference to agricultural communications, it is to the lasting credit of the former expatriate advisor that a system for dealing with the publication of research results was designed and set in motion. The notion of simplifying single research topics in research circulars (fact sheets) which could form pages of a field manual in a dynamic and growing way was a fact of life when the more recent expatriate extension advisor arrived in Lesotho, and 11 circulars had already been printed. Considerable work had also been done in audio-visual aids (Beckerman, 1981). It remained for Extension, however, to facilitate and edit the majority of the circulars now in print, and to extend the system to include the publication of reports, bulletins, special manuals, and handbooks. The work was and is done by commercial printers since the Agricultural Information Services (AIS) capability falls short of Research Division requirements. At this writing 80 circulars, 64 reports, 45 bulletins and 3 handbook/manuals have been published. A standard distribution is made to MOA professionals and other agriculturalists.

Extension research conducted a systematic farmer education program by radio, in Sesotho, on relevant research-generated topics and in the vernacular of the rural community. This activity was performed in collaboration with Agricultural Information Services and Radio Lesotho, but all programs were prepared and voiced by Extension Section personnel in the Research Division. These programs were aired each Saturday morning during the life of the FSR project. Extension research attempted to assist and improve AIS's farmer education effort in Sesotho.

There are several experiences somewhat peculiar to Lesotho which have been published in the interest of sharing them internationally.

Youmans and Holland (1983) describe the special problems encountered in extending FSR results in Lesotho under circumstances in which the male head of the farm household is, more times than not, a migrant laborer. Such persons are farmers in name only since, in reality, they are fulltime miners. The tendency, however, is not to relinquish full decision-making authority to wives who are in fact the farmers on the land. These conditions have special implications to the design and dynamics of extension programs.

Youmans et al. (1984) point out the importance of the village agricultural committees in terms of their value as contact groups, extension education organizations, volunteer leaders, and farmer/teachers. Committee members assist in identification of problems, on-farm research, and extension of results.

Youmans (1985) identifies the critical nature of linkages in the farming systems research process and draws on the Lesotho experience in his discussion. FSR was fully integrated into the Research Division of the Ministry of Agriculture and expatriate advisors worked as one with national colleagues. Extension professionals were assigned to research as full members of the FSR team and an important part of their mandate is to build linkages for joint planning and program delivery among the extension and other technical divisions of the Ministry. Youmans also described linkages at work with other ministries and donor-funded projects.

Extension education played a central and expanding role in FSR dynamics. Extension personnel assigned to the Research Division were members of a team who identified sites, problems, and target farmers.

They work in cooperation with researchers in on-farm research and demonstrations and in the extension of results. In addition, extension took the lead in the organization and delivery of nonformal education programs for three vital groups in the FSR process. These were farmers, chiefs, and extension workers and subject matter specialists of the Ministry of Agriculture. Further, extension developed linkages, advised consulting teams, counseled research scientists, provided feedback, and was responsible for the publication and other dissemination of research results in ways suitable to farmers, extension workers, scientists, and other sector personnel.

3. The Impact of FSR Extension Programs on Farmer Contact Groups

Early in the history of FSR in Lesotho, it became clear that the farmers engaged as cooperating farmers for field trials and enterprise testing would be far too few to constitute an effective network for the diffusion of agricultural innovations. The Lesotho Ministry of Agriculture concluded that an Extension and Communications Section must be attached to the Research Division in order to liaise with other Ministry divisions and to facilitate cooperation and diffusion of innovations among farmers. Thus, a cadre of extension-oriented personnel was present at the outset to deal with the joint problems of farmer organization and extension education. In that connection, in-depth training was conducted for Research Extension Assistants in FSR philosophy and field techniques by national and expatriate practitioners early in the FSR project (Beckerman, 1981).

Considerable talent was brought into the exploration of concepts deriving from extension education, cross-cultural communications, local tradition, group dynamics, and diffusion theory. This served not only to confirm the need to organize a farmer-based diffusion network, but also gave emphasis to the desirability of making such networks as consistent as possible with Basotho tradition. Meanwhile, pitsos were held during the last six months of 1979 in the prototype areas of Molumong, Nyakosoba, and Siloe in order to orient chiefs and farmers in FSR concepts and to introduce expatriate advisors to the farming communities. That series of encounters reinforced the growing

conviction of the need to organize some form of farmer contact group in each farming community within the three prototype areas. The village agricultural committee form of organization gained consensus at that time, and such committees (VACs) were organized and oriented throughout the prototype areas during 1980.

Further, a second series of orientation pitsos was held, together with respective chiefs, in order to explore the notion of village agricultural committees with members of the farming community. These pitsos were organized by personnel of the Extension Section of the Research Division. Discussions in the village achieved farmer acceptance of the VAC concept.

A third series of pitsos was held, one in each village, in order to organize the VACs. It was decided that villagers/farmers themselves should elect their own committee members based on criteria of recognized local leadership and known farming ability. Early in 1980 the village agricultural committees in the three prototype areas were elected. The election pitsos were convened by the respective chiefs and headmen/women and monitored by FSR extension workers.

Much of the remainder of 1980 saw an in-depth orientation of VAC members. They were instructed in their individual and collective roles as representatives of the farming communities, partners in FSR, providers of feedback to researchers and extension workers, disseminators of information, and innovators and teachers.

An important strength of the VAC structures, which in later years were chartered as agricultural cooperatives in Molumong and Nyakosoba, is their function as sounding boards and feedback organizations which inform and guide agricultural research in Lesotho. This, of course, is in addition to member roles as "farmer researchers, disseminators, and teachers". The establishment of VACs in Lesotho has been seen as a major breakthrough in engaging farmers in the agricultural development process.

a. Extension Education Programs

The next step in the farmer contact group (VAC) process was extension education. In order to fulfill expected roles, members not only had to be refreshed periodically on the nature of those roles, but also needed in-depth extension education in agriculture. This agricultural extension derived basically from two sources. The first was knowledge held by Research Division and FSR practitioners which could contribute to solution of local problems as identified by farmers themselves. The second had as its basis the results of on-farm research in progress, which provided sound recommended changes in farming practices and products. The intended outcome of the extension education program among VACs was the improvement of the productivity, the economics, and the quality of rural life.

In July and August 1981, extension education programs were held at the Farmer Training Centers (FTCs) in Mokhotlong, Matela, and Mohale's Hoek for VAC representatives from Molumong, Nyakosoba and Siloe, respectively. The curriculum was standardized as a result of inputs from research and extension officers and consultation with farmers. Technical instruction was given in seed-bed preparation, manuring, use of inorganic fertilizers, fodder seed, grains and pulses, recommended varieties of various crops, and planting times (agronomy). Calibration of ox-drawn planters, plows, and other equipment was taught (farm machinery). Instruction and demonstrations were given in seed-bed preparation for vegetable seedlings, early production of cabbage, potato production, direct sowing of vegetable seeds, the compost pit/heap, planting of young fruit trees and pruning of established fruit trees (horticulture). VAC farmers were likewise instructed in the feeding of the dairy cow (livestock), grazing control regulations and rotational grazing (range), simple record keeping (farm management), and local markets (marketing).

VAC members were questioned about the level of instruction. Rating the instructional level as appropriate were 87% of the respondents, while 8% felt it was inappropriate (too high or too low), according to Sefeane (1981).

Questions were also asked about teaching methods and respondents were instructed to list two preferences. Learning by doing scored 54 marks while listening to instructors was scored 63 times. Group discussions drew 59 scores while observation was checked only 3 times. As to clarity of instruction, over 90% of the respondents thought the presentations were clear and to the point. A full 100% indicated the program was relevant to problems on the farms.

Sefeane (1981) concluded that farmers fail to adopt innovations because they lack the appropriate skills. He was prompted to classify farmers as backyard, middle, and commercial/merchanized. It was perceived that technology overload is a danger in extension education programs. He added that farmers are generally intelligent and that recommendations must be compatible, triable, visible, and relevant in order to be adopted. His field recommendations at the time centered on a call for FSR trials on cereals and fodder crops. The Sefeane report documented useful information at the input, activities, people involvement, and reaction levels of evidence according to Bennett (1980).

A second farmer (VAC) extension education program was delivered from 29 Mar-30 Apr 1982, for committee members from the three prototype areas. Attendance was 98. Content of the curriculum included the responsibilities of VACs and values clarification. Technical education was provided on a wide variety of subjects in agronomy, plant protection, farm machinery, horticulture, animal science, and veterinary science.

Farmer contact group (VAC) members' reactions were positive as indicated by the number and quality of the questions raised for discussion. A post-instruction evaluation was conducted among 47 VAC

Figure III-J-1. Members of Village Agricultural Committees gather for training at the multipurpose Field Research Center constructed by FSR in the Nyakosoba prototype area.

Figure III-J-2. Basotho farmers singing after an extension training session in Nyakosoba prototype area.

members who attended the 1981 instruction. Results showed that committee members understood their roles as coordinators among farmers and research officers, and advisors to farmers on agricultural activities. They also understood and used organic manures, and had begun to try inorganic fertilizers. Many respondents reported planting barley, oats, and lucerne for fodder, although others had not attempted to grow fodder crops. Farmers generally recalled recommended varieties of peas, maize, sorghum, wheat, and beans and had expended more money to purchase improved seed. Some 20 of the 47 respondents reported having begun to cull livestock. Respondents generally understood and favored new grazing control regulations (Matobo el al., 1982).

In addition to the evaluation of the prior year's extension education program, another instrument was administered in order to evaluate the immediate reaction to the 1982 courses. All respondents reported that the discussions on the responsibility of the VAC's had been helpful. Response to questions about agronomy indicated that topics were generally clear and instructional methods appropriate.

Some 56% of the participants reported that they were able to read the instructions and use pesticides. Others would only use them if somebody read the instructions for them, and a minority stated that it was easier to read instructions than to actually use the chemicals. A majority of the participants were satisfied with what they had been taught in horticulture.

An extension education course for 30 Molumong VAC members was held at the Mokhotlong Farmer Training Center in March 1983. The content of the course was again delivered by national research and extension officers in Sesotho, advised by expatriate FSR practitioners and researchers. As before, it included technical update material on a variety of topics in agronomy, horticulture, plant protection, and livestock, but also included marketing and rural sociology. Responses were generally positive.

In early 1983 a series of events occured which radically altered the extension education model for VAC members in terms of venue, structure, and strategy. In January and February, three field research centers, constructed under the Farming Systems Research Project, were officially opened in Molumong, Nyakosoba, and Siloe. Each center consisted of housing for resident Research Extension Assistants and visiting officers, a large shed with storage rooms and a water collection tank, and limited land. This development was hailed by Lesotho's Minister of Agriculture as the commencement of "people's universities" where advancements in agriculture and domestic economy could be shared with the people in their own communities. Concurrently, recommended improvements and technologies emerging from FSR on-farm trials work began to multiply. Finally, research extension personnel and the director of research began to explore ways to maximize farmer education while minimizing costs. This was important, anticipating the eventual decline of donor funding. It was then that the change of venue, structure, and strategy for VAC education was conceived (Youmans, 1983).

The change of venue of VAC education from the traditional boarding Farmer Training Centers in Matela and Mohale's Hoek to newly opened field research centers at Nyakosoba and Siloe involved reorientation of VAC members.

Maintenance of high attendance rates at educational events and reduction of attrition became primary concerns. Making instruction sufficiently interactive and interesting to assume voluntary attendance presented a singular challenge and represented an abrupt departure from the former "captive audience" situation at the Farmer Training Centers. An experimental model for the education of VAC members at Nyakosoba and Siloe was designed for testing during April 1983 (Youmans, 1983).

The structure was to be a three-day short course . The curriculum was to include orientation by research extension officers, subject matter education in Sesotho by national research officers, and field trips to crop and horticultural sites for participants. The short course for Nyakosoba and Siloe VAC members were held in April of that year.

Education at both sites included orientation, topics in agronomy, an agronomy field trip, topics in horticulture, a horticulture field trip, farm machinery, calibration of ox-drawn planters, and topics in livestock and plant protection. Items liked about the three-day short course at the field research center were many and varied. Included were such comments as relevant topics, good conduct, impressive teaching methods, good course content, good lecturers, and adequate transportation back-up. This account and subsequent evaluation seems to have dealt with specific program results at the inputs, activities, people involvement, and reaction evidence levels.

By the time extension education events were scheduled for 1984, the Nyakobosa VACs were operating under a central cooperative framework. Short courses were held for those VACs and for the Siloe VACs in September 1984. Joint attendance was 87 persons. Curricula centered on horiculture, agronomy, plant protection, fodder production, and demonstration and calibration of Ariana ox-drawn machinery.

For course content to be taught at future farmer educational events, 40 participants (29%) wanted continued education in agronomy, 22 (16%) felt a need for training in poultry, 19 (14%) wanted more education about ox-drawn equipment, 15 (11%) indicated a need for more knowledge in horticulture, and 14 (10%) wanted to learn more about livestock/animal diseases (Youmans, 1983).

A "spin-off" extension education program of FSR in Lesotho was nutrition education. Women farmers who were successful and enthused with home garden activities of FSR in Nyakosoba expressed a need to learn methods of storing some of their garden produce and of preparing nutritious meals for their families using home grown vegetables. The Extension Section of the Research Division responded by jointly organizing and presenting a course with the Nutrition Section of the

Ministry at Nyakosoba. This course was organized around the themes of production, preservation, and preparation of home-grown food. It targeted 100 women who had been involved in home garden education, and was held at the Nyakosoba field research center in March 1983 (Ramakhula, 1983).

Ramakhula reported that women farmers' reaction to this course was most positive. They were highly interactive, worked long hours, and compiled home cookery recipe books. They also organized a cookery club which agreed to meet monthly with the district nutritionist for lessons on food and family nutrition.

The Extension Section also addressed the need for home economics and management instruction voiced by women farmers by coordinating with home economics assistants in Mohale's Hoek and Maseru districts in conducting home economics courses at Siloe in February 1984 and at Nyakosoba in May 1984. A total of 92 women consistently attended these courses, including many teenage girls, in addition to women farmers. Reactions to the instruction were very positive as demonstrated by the frequency and variability of questions and requests for advice, and by the women's willingness to supply all the home-grown food for the courses and to contribute to the purchase of supplementary items.

Also in 1983-84, farmers' field days were held in Siloe (livestock), Nyakosoba (crops), and Molumong (crops). Altogether 140 farmers attended those field days where agricultural subjects were observed and discussed. Field days for farmers continued throughout 1985-86 based on the extension demonstration program. Attendance was consistently high.

Since 1981, extension research personnel had prepared and broadcast agricultural radio programs over Radio Lesotho each Saturday morning. That extension education program was in response to indications in the FSR Baseline Survey (Butler, 1982) that farmers in the prototype areas depended importantly on the radio for information about agriculture (Trail, 1982). The Research Division of the Ministry of Agriculture, in the context of the FSR extension education effort, consistently produced 52 radio programs annually.

b. The Evaluation Problem

The evaluation problem associated with the impacts of FSR extension education programs on members of farmer contact groups centered on the need to know the lasting effects and benefits of those programs beyond the rather soft perceptions about input, activities, people involvement, and reactions. In the context of FSR philosophy and practice, it is necessary to determine the kinds and extent of behavior changes among the VAC membership in terms of what has been learned and retained in both the knowledge and skills, and how that is associated with attitudes and aspirations. Further, since the FSR strategy is ultimately results oriented, the degree of practice change among the clientele needed to be determined and, where possible, the real benefits (end results) ascertained.

c. Methodology

The methodology selected for evaluation is the reflective appraisal of programs (RAP) strategy. This is an approach developed by Bennett et al. (1982). Bennett developed a method of appraising extension program impacts through reflective perceptions of participants as related to a hierarchy of evidence of learning levels. Included in the hierarchy are (1) inputs, (2) activities, (3) people involvement, (4) reactions, (5) KASA change, (6) practice change, and (7) end results. The first four of these seven levels of evidence (Bennett, 1980) have been reported. Analysis of the KASA, practice change, and end results levels added strength to the evidence of the program impacts and complete the evaluative profile of the educational intervention (Bennett, 1977). The RAP state of the art methodology is suited to the collection and evaluation of data at all seven evidence levels and aims toward seeking information from as high a level on the evidence hierarchy as possible.

Data on the impact of FSR extension programs on members of farmer contact groups in Lesotho were collected by means of carefully designed interview questionnaires. It was decided to seek and collect data at evidence levels 5, 6, and 7, namely KASA change, practice change, and end result as directed by RAP methodology (Bennett, 1982). The programs to be studied had taken place over a time span long enough to permit desired change, and even end results, but not so long as to be severely hampered by memory lapse.

d. Results

The data gathered from the farmer contact group sample (Table III-J-1) were checked and coded for computer analysis.

Table III-J-1. Biographical data of farmer contact group sample.

	Women	Men	Total
Sample size	41 (76%)	13 (24%)	54
Ave.Age (range)	44 (21-71)	54 (39-70)	46.6(21-71)
No. years farming experience (total=804)	-	-	14.9 (0-46)
No. persons who attended school	-	-	48 (89%)
Ave. standard attained	-	-	4.2 (1-7)
No. families with members in migrant labor (mines)	-	-	43 (80%)
No. of migrant workers members/family	-	-	2 (1-8)
Total no. migrant workers (mean)			87 (1.6)

(1) Biographical Data

Age and Sex. The age range for the 54 respondents was 21-71 years with the mean age 46.6 years. Of the sample, 41 (76%) were women and 13 (24%) were men. This finding is expected to extend to all members of the farmer contact groups. The female ages ranged from 21-71 (mean 44%). The range for males was from 39-70 years (mean 54%).

Farming Experience. The respondents reported total farming experience of 804 person-years (mean 14.9 years/respondent). The range in farming experience was 0-46 years.

(2) Farm Characteristics

Most of the farm characteristics reported are based on 53 responses. Accurate farm size could not be determined since many respondents reckoned size in number of "fields" while others reported measurements in acres.

Field Crops. Respondents said they grew maize, sorghum, wheat, beans, and peas on their land. These crops were reported roughly in that order.

Farm Machinery. Farm machinery was owned by 29 respondents (55%). Of those owning machinery, the most frequent implement reported was the plow. The numbers of cultivators and planters were comparable. Harrows were rare. Presumably all machinery reported is ox-drawn. One person owned a petrol engine pump for irrigation.

Horticulture. Horticulture crops were somewhat more varied, and included cabbage, tomatoes, beetroot, carrots, radish, potatoes, pumpkins, spinach, onions, and lettuce. It is significant that 50 of 53 respondents (94%) grew home gardens. This finding is solidly related to FSR horticultural research and extension education programs. Likewise, 47 of 53 (89%) participated in communal gardens. While the communal garden movement is officially the province of the Ministry of Cooperatives and Rural Development, there is reason to believe that intense activity by FSR-related Research Extension Assistants and Peace Corps volunteers in Siloe and Molumong is directly associated with this accomplishment.

Weeding and Pest Control. All 53 respondents to farm characteristics questions said they weed their crops and gardens. All 53 reported using the hand hoe for this task. No chemical herbicide use was reported. In the realm of insect and plant disease control, 36 persons (68%) reported carrying out this task. Although certainly weeding and pest control activities were not uncommon in Lesotho prior to 1979, it is felt that this reflects intense efforts by FSR extension work.

Animal Ownership. Ownership of range animals showed 26 respondents (49%) owning sheep with a mean of 13 animals. Cattle were owned by 32 (60%) persons averaging 6 animals per owner. Ownership of other animals was reported by 39 respondents (74%). A mean of six other animals per owner included goats, horses, and donkeys. Home-based animals included milk cows, swine, and poultry. Mean milk cow ownership was three animals among 23 respondents (43%). The 20 farmers (38%) who kept swine owned a mean of two pigs each. Poultry were kept by 43 respondents (81%) who owned a mean 10 birds apiece. Presumably these were mainly local breeds.

Farm Labor. In 49 cases (93%) members of respondents' families worked on their farms, a mean of three family members per household, yet 23 respondents (43%) hired outside farm labor during the year.

Marketing. Of 53 respondents, 25 (47%) produced more goods than their families and animals consumed. Among such goods were beans, maize, wheat, peas, sorghum, cabbage, carrots, and potatoes. These goods were actively marketed. Most farmers sold goods locally for cash.

Farm Records. Seven members of farmer contact groups among the 53 respondents kept farm records (13%). No extension education effect is inferred here since the farm records program is a different FSR activity.

(3) Extension Education Indicators

Respondents were asked to provide certain feedback indicators in order to guide current and future extension education program planning.

Farmer Field Day Attendance. Forty-five of 54 persons attended field days (83%).

Radio Programs. Radio programs were regularly or frequently heard by 41 of 54 persons, a 76% positive response. All respondents indicated they learned well by radio.

Validation of Content Recall. As extension education programs were described to respondents during the interview process, a function designed to stimulate recall (Bennett, 1982), they were asked to indicate the accuracy of the program content description. All 54 respondents said the descriptions were accurate so far as they knew.

Reaction Level. On the occasion of the personal interview, respondents were asked to what extent the extension education activities met their expectations at the time. Without exception, they replied that they had done so to a great extent.

Methods Preference. The illustrative talk was preferred by three people (5%), demonstration was preferred by one person (2%), field trip/field days was indicated by one person (2%), but a combination of

methods was preferred by 47 respondents (87%). Since radio programing was also widely accepted, it is clear that an integrated, multisensory approach to extension education in Lesotho is preferred by the farmers themselves. This finding is consistent with FSR and extension dynamics as they have evolved.

Venue of Extension Education. Respondents were asked to indicate their preference of a venue for extension education programs of either Farmer Training Centers (FTCs) or the Field Research Centers (FRCs). Farmer Training Centers were preferred by four people (7%), but field Research Centers were preferred by 50 people (93%). It is dramatically clear that farmers prefer extension education which takes place near their homes. That finding, in addition to the vote of confidence for radio, speaks strongly for localized extension programs. This is consistent with the site-specific tenet of FSR and extension education as it has evolved.

Recommendations by Farmers. All members of farmer contact groups who were interviewed were asked what suggestion they had for the improvement of the Research Division's farmers educational programs. Forty-four persons (82%) had no suggestions, however, 10 (19%) gave recommendations which may be significant despite their infrequency. The prevalent suggestion was that extension courses be brought to the village level since even the Field Research Center was distant from respondents' homes.

(4) KASA and Practice Change Results

The impacts of extension education programs were measured in terms of behavioral change among clients, a 54-person sample of farmer contact groups. Data included self-perceived changes in their own knowledge, attitudes, skills, aspirations, and agricultural practices related to their involvement in farming systems research extension programs.

KASA Change. Members of the sample responded to standardized questions about the changes in Knowledge, Attitudes, Skills and Aspirations (KASA), and practice change in the areas of agronomy, horticulture, plant protection, farm machinery, and animal and range management related to participation in extension programs. Their responses were on a standardized Likert scale (Bennett, 1982) as follows:

- to a great extent (3)
- to a fair extent (2)
- to a slight extent (1)
- not at all (0)
- other (z)

The values in parentheses were used to encode and record the responses onto a numerical matrix. The matrix values were then coded and entered into the computer for compilation and analyzis. The data to be discussed are the results of this process.

The KASA change values are retained in separate change components in order to insure the distinguishibility of response value categories. Thus, one is able to determine from the data the percentage and number of respondents who gained knowledge to a great extent (3) in agronomy as a result of their participation in extension education programs during the period under study. Likewise, one can easily see the number and percentage of those who learned plant protection skills to a slight extent (1), or those who experienced no practice change (0) in animal and range management.

Generally, the data support impressive KASA changes, tending heavily toward change to a great extent in all technical agriculture subject matters as a result of having participated in FSR extension education programs, and as perceived by the members of farmer contact groups themselves.

Practice Change. In the practice change arena, the results of the extension education programs through farming systems research are likewise impressive and far exceed the target adoption rate of 5% stipulated in the FSR project paper. Since KASA change is prerequisite to practice change, it is only fair to say that it is also easier to achieve. The incentives of mono-cash cultivation scheme and/or coercion are the only exceptions to that statement which come to mind. It is expected that practice change will happen to a lesser degree and with greater variablity than KASA change, and one can expect many constraints to practice change which are beyond the control and influence of the extension educator.

The highest degree of practice change is found in agronomy, followed by horticulture, farm machinery, plant protection, and animal and range management in that order.

KASA Change and Intensity of Extension Education. When KASA data are related to the number of short courses each respondent attended, a slightly different configuration emerges. There were 5 respondents who attended a single course, 17 who attended two courses, 18 who attended three courses, and 14 who had been to all four courses. The KASA scores are high with little variability among the participants in one course. Responses remain rather high but gain variability as people benefit from having attended two farmer education courses. KASA values for respondents attending three courses seem to gain in cumulative strength and also in variability. Respondents attending all four courses report very high KASA scores and variability decreases. That is, quality of learning increases together with intensity of extension education. This is clear in all agricultural subjects.

Although, as expected, cumulative practice change lags somewhat behind cumulative KASA change, the practice change increases with intensity of extension education. This can be seen, with minor fluctuations, in all agricultural subjects. Apparently gains in practice change are associated with gains in KASA change, and both kinds of change are produced by extension education programs of increasing intensity.

Constraints to Practice Change. Information about constraints to practice change was obtained from two sources. First, the "open-end probe question" elicted a great deal of commentary about constraints. Second, the questionnaire asked the respondent if there were changes he/she really wanted to make on his/her farm but was unable to do so, to please explain why. Commentary is abundant but variability is less pronounced. Thus, it is possible to quantify these data, at least in terms of cumulative responses.

Constructive change in range management and improvement was the constraint most voiced (35 respondents). They said that individual farmers are powerless to make a difference, that people do not care, that people will not cooperate in the conservation of a communal resource, and that collective range management will require vast public education. Second was the non-availability of personal finances to enable desired change. Third, the non-availability of pesticides locally. Fourth, inadequate training. Other constraints mentioned were pest and animal damage to crops, lack of resources, and drought or unavailability of irrigation water.

The constraints to practice change as perceived by members of farmer contact groups are almost totally outside the scope of farming systems research and extension.

Although important extension successes were amply demonstrated in this study, it will require a comprehensive and enforceable nationwide range conservation policy if significant breakthroughs against range degradation are to be achieved. If credit is not available to individual farmers nationwide, investment in resources or new enterprises may not be widely made. If pesticides are not made available to farmers in remote areas on time then they will likely not be used when effective or at all.

The FSR extension education programs achieved very significant successes among members of farmer contact groups in the areas of KASA and practice change. However, Farming Systems Research and Extension is a dynamic development strategy and does not operate in a vacuum. The infrastructure conducive to agricultural development must be in place, credit and inputs must be available, and markets must be developed and protected in order for farming systems research to have its maximum effect.

(5) End Results

Despite the constraints voiced above, there were widespread practice changes among members of farmer contact groups, according to their perceptions, induced through the extension education programs of FSR. However, end results--real benefits to farmers--constitute the final measuring stick to determine the value of farming systems research and extension. In consultation with research colleagues, several indicators were selected as factors to be determined in the assessment of real benefits (end results) of Farming Systems Research to members of farmer contact groups as perceived by them to be related

to extension education programs. These indicators, while not exhaustive, are thought to be consistent with the stated objectives of the Farming Systems Research Project in Lesotho.

Responses from the 54 people in the farmer contact group were analyzed by computer (Table II-J-2). Since the 'other' and the 'no significant benefits' categories had a 100 percent non-response, they have been eliminated from the data.

The most significant benefit was 'better meals for family', reported by 80% of the respondents, which seems closely linked to the next most significant benefit, 'stored and/or preserved food', reported by 67% of the respondents. This appears to be related to the nutrition and domestic management extension education programs described previously. The finding is also likely related to the high incidence of KASA and practice change in horticulture since stored and preserved food and subsequent dietary improvements are thought to be related to home-grown vegetables. These two reported benefits are probably sex-related since education in nutrition and home economics was given only for women, and the majority of the respondents were also women.

The third most significant benefit, which is not sex-related, is 'higher crop yields', a benefit reported by 65% of the respondents. This is followed by 'better condition of animals' and 'able to purchase improved inputs', according to 50% of the respondents. These three appear to be linked and are likely influenced as well by 'more income from farming' (39%) and 'acquisition of better animals' (39%). The 43% of the sample who reported 'more trading with neighbors' and the 37% who benefited from 'better markets' provided evidence of an improvement in local means of disposing of surpluses.

Table III-J-2. End results (real benefits) to members of farmer contact groups of extension education programs, Lesotho, 1985.

	Indicators[1]												
Response	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM
Yes	39	43	15	39	67	80	43	65	50	50	0	17	37
No	57	52	81	56	31	19	39	31	37	44	93	44	9
Not applicable	0	0	2	4	0	0	11	2	7	2	0	33	15
No response	4	6	2	2	2	2	7	2	6	4	7	6	39

1. AA = More income from farming.
BB = More trading with neighbors.
CC = Acquisition of more property.
DD = Acquisition of better animals.
EE = Stored and/or preserved food.
FF = Better meals for family.
GG = Better education for children.
HH = Higher crop yields.
II = Better condition of animals.
JJ = Able to purchase improved inputs.
KK = Able to secure credit/loans.
LL = Improved farm records.
MM = Better markets.

'Better education for children' is a desirable and positive benefit. Its direct relationship to farming systems research and extension is tenuous, although the awareness and cumulative educational "product" among parents probably has some influence. A few respondents who reported this benefit could not relate it to the farming systems research experience.

Neither farm records specifically nor farm management in general were among the agricultural subjects emphasized in the extension education programs. Therefore, it was not surprising to find a low number (17%) reported 'improved farm records' as a benefit.

The 'acquisition of property' was reported as a positive outcome by 15% of the sample. Given the value of some property such as ox-drawn equipment, tools, etc., 15% may not be as insignificant as it seems.

A resounding nonbenefit, and one reported by 93% of the sample was the 'ability to secure credit or loans'. The provision and sustenance of credit and loans is not among the components of farming systems research philosophy and dynamics. It is, nonetheless, a helpful if temporary resource and mention has been made of the potential of farm credit. By the end of 1984, its procurement seems to have been beyond the capability of farmer contact group membership. This situation has changed dramatically since farmer contact groups in Molumong and Nyakosoba were trained in cooperatives early that year. The training helped qualify the membership for credit and loans through the Agricultural Development Bank. Loans were subsequently procured by those groups and the nonbenefit became a distinct benefit.

Real benefits have accrued to members of the farmer contact groups as a result of having participated in a variety of extension education programs within the context of FSR. Significantly, these data analyzed on the basis of those respondents attending one, two, three, and four extension courses indicate additional benefits with increased intensity of extension education (Table III-J-3). The evidence certainly suggests that real benefits to farmers, along with associated gains in KASA and practice change can be achieved through continued extension programs.

(6) Farmer Contact Groups as an Innovation Diffusion Network

Farmer contact groups were organized, not only as target audiences for extension education programs, but also as components of an innovations diffusion network. It was felt that a few cooperating farmers, on whose lands on-farm research and demonstrations were to be conducted, would surely adopt recommended crops and practices generated by such joint activity. It seemed logical as well that farmer contact group members, the target of intensive extension education, would be prone to significant degrees of KASA and practice

change (adoption). If such desired adoption was to happen on a wider front, however, it was felt that farmer contact groups would have to disseminate a great deal of information among other farmers. They would function as an innovations diffusion network.

Table III-J-3. Growth and benefits to farmers with intensity of extension education programs, Lesotho, 1985.

Response	Percentage response for one course												
	AA[1]	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM
Yes	40	60	0	20	40	60	20	40	20	40	0	0	40
No	60	40	100	80	60	40	60	60	60	40	100	80	0
Not applicable	0	0	0	0	0	0	20	0	0	0	0	0	20
No response	0	0	0	0	0	0	0	0	20	20	0	20	40

Response	Percentage response for two courses												
	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM
Yes	24	29	6	53	65	82	35	53	53	35	0	18	24
No	71	65	94	41	35	18	35	47	47	65	94	59	6
Not applicable	0	0	0	6	0	0	18	0	0	0	0	24	24
No response	6	6	0	0	0	0	12	0	0	0	6	0	47

Response	Percentage response for three courses												
	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM
Yes	44	44	17	33	78	83	44	83	50	6	10	11	39
No	56	50	78	61	22	17	44	11	33	33	94	28	11
Not applicable	0	0	6	6	0	0	11	6	17	6	0	61	11
No response	0	6	0	0	0	0	0	0	0	0	6	0	39

Response	Percentage response for four courses												
	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM
Yes	50	50	29	36	64	79	57	64	57	57	0	29	50
No	49	43	64	57	29	14	29	29	21	36	86	36	14
Not applicable	0	0	0	0	0	0	0	0	7	0	0	21	7
No response	7	7	7	7	7	7	14	7	14	7	14	14	29

1. AA = More income from farming.
BB = More trading with neighbors.
CC = Acquisition of more property.
DD = Acquisition of better animals.
EE = Stored and/or preserved food.
FF = Better meals for family.
GG = Better education for children.
HH = Higher crop yields
II = Better condition of animals.
JJ = Able to purchase improved inputs.
KK = Able to secure credit/loans.
LL = Improved farm records.
MM = Better markets.

When data are grouped according to age interval and farming experience, some interesting patterns begin to emerge (Table III-J-4). For example the total sample of 54 respondents told 842 persons about agricultural innovations, a multiplier effect of 15.6 in the "told" category. Those same 54 persons showed 315 others new or different things on their farms, for a multiplier of 5.8. Finally, the 54 respondents estimated that 268 other farmers had observed innovations on their farms, a multiplier of roughly 5. The largest number of respondents (39%) were in the 41-50 age group. They were responsible for telling 460 (55%), showing 204 (65%), and facilitating observation by 167 (62%) nonmembers of agricultural innovations. With 30 years cumulative farming experience (roughly 4%) they appear to have performed beyond expectations. Why this age group, despite being so numerous, has so little farming experience is an interesting question not answered by this analyzis.

The fact remains that farmer contact groups have proved to be effective disseminators of agricultural information and diffusors of innovations. A mean multiplier effect of 8.8 for all diffusion forms analyzed was found. If that factor is extended to all 224 farmers holding contact group membership, farmer contact group members have diffused innovations derived from Farming Systems Research to nearly 2000 persons during the period under study. Actual adoption rates among that population cannot be determined from the current data.

e. Summary

From the foregoing analysis, it is clear that positive changes in knowledge, attitudes, skills, and aspirations have been achieved among members of farmer contact groups through Farming Systems Research extension education programs. It was also demonstrated that significant positive practice change has been achieved among the same membership. These KASA and practice changes led to measurable and lasting benefits (end results) among the membership of farmer contact groups. The incidence of change bears a positive and increasing relationship to intensity of extension education programs, an "extension effect".

Table III-J-4. Diffusion effectivenss of respondents according to age and farming experience, Lesotho, 1985.

Age range (no.)	Age (%)	Told	Showed	Observed	Years farming experience
21-30 (6)	11	92	26	18	27
31-40 (10)	19	77	23	25	57
41-50 (21)	39	460	204	167	30
51-60 (9)	17	146	31	35	167
61-70 (7)	13	37	11	18	191
71 (1)	2	30	20	5	30

4. The Effects of FSR Extension Education Programs Among Chiefs, Headmen, and Headwomen in the Prototype Areas

a. Chiefs, Headmen, and Headwomen

In Lesotho the rights to becoming chief are hereditary in that chiefs are of royal blood, the descendents of King Moshoeshoe I or other historic African figures. In some cases, headmen were appointed by early royalty and although they were not of the royal line, their positions became hereditary as well. Women appear as both chiefs and headwomen in Lesotho. A woman becomes a chief if her husband dies and she has no son, or if her eldest son is too young.

Traditionally, chiefs are local leaders. They hold power to convene public assemblies, grant grazing access to the public, hear complaints, and resolve conflicts. They also control the movement and guarantee the safe passage of outsiders within their jurisdictions. As a natural extension of that tradition, well informed and supportive chiefs can become important facilitators of desired change (Youmans, 1985).

b. Extension Education Programs

Research Division personnel, along with expatriate Washington State University FSR advisors, realized the importance of local chiefs in advancing the FSR and extension processes. In recognition of their critical and traditional role, research and extension personnel presented extension courses for the chiefs and headmen/headwomen in the three prototype areas.

In February 1983 and 1984 extension short courses were held for village chiefs, headmen, and headwomen at the Matela Farmer Training Center. Attendance was 36 and 31, respectively. Leadership styles and communication skills were taught, and the role of farmer contact groups was explained. The intervention of chiefs themselves as promotors of small agricultural groups and of needed change was explored. Government regulations and policies on agricultural research, basic grains, new crops, grazing control, livestock importation, erosion control, and afforestation were discussed by authorized experts. The advantages to be gained through proper stocking rates and rotational grazing were pointed out. Finally, an explanation of FSR and the role of chiefs in agricultural development was emphasized. In making chiefs partners in the FSR process, a potential constraint was reduced and a major resource was gained.

c. The Evaluation Problem

As in the case of farmer contact groups, the research problem was to determine the lasting effects of extension education programs among these chiefs, headmen, and headwomen. It was important to know whether FSR extension has produced changes in the members of this clientele in such important areas as knowledge, attitudes, skills, aspirations, practice change, and end results. Only in that way could programs be assessed, modified, and improved.

d. Methodology

The RAP methodology was again selected. The information was collected by means of an interview/questionnaire process with all program participants, and the data analyzed using the most appropriate analytical methods.

e. Results

(1) Reactions

When asked to respond to what extent the course(s) met the respondents' expectations at the time, all 20 respondents indicated that it (they) had done so to a great extent.

(2) KASA and Practice Change

Respondents were asked standardized but modified questions about knowledge, attitudes, skills, and aspirations which were acquired, developed, or enhanced as a result of their participation in the short course(s) held for their benefit. They were also asked about the levels of subsequent practice change directly associated with the learning attained in KASA. The response scale was again coded:

- to a great extent	(3)	- not at all	(0)
- to a fair extent	(2)	- don't know/don't recall	(x)
- to a slight extent	(1)	- other	(z)

Extension Education Programs. There were 19 original topics taught to chiefs and headpersons in the short course(s). These were numbered 1 to 19 in the data, minus topic 8 "stocking rates" which was repeated on the questionaire in number 13 (Table III-J-5).

KASA Findings. The respondents reported high incidences of perceived changes ("3" and "2" scores totalling 80% or more) in leadership and communications (1), the role of chiefs in agricultural development (2), the role of the farmer contact groups (3), the role of chiefs as facilities of groups (4), their attitude, as chiefs and headmen/women, toward agriculture (5), the Chiefainship Act of 1968 (9), grazing control regulations (10), and anti-erosion works regulation (18).

Intermediate scores for KASA changes were reported for the farming research concept (6), agronomy research in grain and crops (7), rotational grazing (11), animal science (17), and forestry/woodlot policies (19). The percentage of respondents reporting don't know/don't recall was between 30% and 36% for animal science, forestry/woodlot, and agronomy.

In marked contrast, the data show slight KASA change and non-recall on topics 12-16. These topics about which comparatively little change was achieved and a great deal of non-recall experienced were range research in the prototype areas, stocking rates, livestock production and policy, importation of livestock, and the abattoir.

Practice Change. Practice change data tend to show a similar configuration as KASA change data, but with considerably more variability and nonadoption. The low incidence of practice change (nonadoption) of topics 12-16 seems to be directly related to inadequate learning and low recall about those topics. Since these topics account for 27.8% of the extension education programs among chiefs, headmen, and headwomen, the causes behind this shortfall should be investigated.

Constraints to Practice Changes. Constraints to practice change were expressed freely by respondents. Some were related to the non-learning/non-recall phenomenon described above. Others were voiced more in the context of frustration over not being able to apply new capabilities developed in the KASA change process. Some of the constraints specified included the difficulty of promoting rotational

Table III-J-5. Response of chiefs and headmen/women to questions about impacts of extension education courses.

	KASA (%)[1,2]					Practice change (%)[2]				
	3	2	1	X	0	3	2	1	X	0
Leadership styles & communication	75	12	3	10	0	15	50	15	10	10
Role of agric. development	80	14	1	5	0	25	35	30	5	5
Role of farmer groups	64	22	3	11	0	15	45	20	10	0
Role as facilitators of groups	54	29	0	15	2	15	45	10	15	15
Attitudes towards agriculture	83	6	1	10	0	50	30	10	10	0
FSR concept	43	26	10	18	3	20	40	10	25	5
Agronomy	35	13	16	36	0	10	25	15	40	10
Chieftainship Act of 1968	79	8	3	10	0	55	20	5	20	0
Grazing control regulations	82	14	4	0	0	25	15	20	0	40
Rotational grazing	56	13	11	15	5	10	10	20	15	45
Range research (prototype areas)	18	16	6	55	5	0	5	10	40	30
Stocking rates	30	11	2	53	4	15	5	10	40	30
Livestock policies & production	26	4	1	69	0	10	15	5	70	0
Importation of livestock	24	5	0	71	0	15	10	5	70	0
The abbatoir	0	15	0	85	0	0	5	0	75	20
Animal Science	49	12	9	30	0	40	15	10	30	5
Anti-erosion works regs.	68	18	2	10	2	45	20	10	10	15
Forestry/woodlot policies	44	16	5	30	5	10	15	20	30	25

1. Values are the mean percentage of scores for the four components, knowledge, attitudes, skills, and aspirations. With very few exceptions, scores were similar for all four components for any particular topic.

2. Scale: to a great extent (3), to a fair extent (2), to a slight extent (1), don't know/don't recall (X), not at all (0).

grazing among people who do not understand the concept, young trees being destroyed by herdboys and animals, villagers not understanding grazing control regulations, lack of dissemination of range research results among chiefs, and quarrels among some farmer contact group members. Other constraints were lack of knowledge by chiefs of agronomy research results, lack of knowledge about tree seedling procurement, incomplete understanding of stocking rate concepts, non-response to chiefs' leadership, frustration over non-function of the abattoir, and non-interest in forestry.

More constraints included the need to know how to care for young trees and incomplete understanding of chief's role in agricultural development. While most of these constraints were voiced by individual respondents, the constraints to grazing control, stocking rate attainment, and/or rotational grazing were mentioned by 14 (70%) of the respondents.

(3) End Results

Of the 20 chiefs and headmen/women who participated in FSR extension education programs, 19 (95%) are active in decision-making about agriculture. All 20 (100%) benefited significantly from these educational programs and actively support farming systems research as a development strategy.

f. Summary

Chiefs and headmen/women from villages in Farming Systems Research prototype areas participated in extension education courses in 1983 and 1984. A sample of 20 of these participants reported significant KASA changes in several subjects. The same respondents indicated having made significant practice changes in the same subjects in their role as village leaders, although there was more variability in the intensity of practice change. The subjects taught which elicited such positive responses at these higher evidence levels included leadership styles and communications, role of chiefs in agricultural production, role of farmer contact groups, role of chiefs as facilitators of groups, chiefs' attitudes toward agriculture, farming systems research concept, agronomy research in grain and crops, Chieftainship Act of 1968, grazing control regulations, rotational grazing, animal science in prototype areas, anti-erosion works regulations, and forestry/woodlot policies.

In contrast, consistently more than 50% of the respondents, the percentage sometimes rising to 85%, either failed to learn or could not recall the content of extension education in the topics of range research in prototype areas, stocking rates, livestock policy and production, importation of livestock, and the abattoir. From the data at hand, it is not possible to explain this contrast. Important constraints to practice change were found in the areas of grazing control, stocking rate, and rotational grazing.

Chiefs and headmen/women are active in decision-making about agriculture, benefited significantly from FSR extension education programs, and actively support farming systems research as a development strategy.

5. The Impact of FSR Extension Education Programs on District-Based Extension Workers and Subject Matter Specialists

a. Extension Workers and Subject Matter Specialists

The Lesotho Ministry of Agriculture and Marketing carries out its field operations largely through district-based personnel who work and reside throughout the 10 administrative districts of the country. This cadre of agricultural workers, who report to a district agricultural officer, includes extension workers and subject matter specialists. Both groups are fundamentally important to agricultural development. Extension workers are engaged in extension education programs directly with farmers, while subject matter specialists provide technical expertise and guidance for extension workers who are largely generalists. The latter may call on the subject matter specialists to address farmers about specific topics if the situation requires a direct exchange.

Most extension assistants, who are the front line field extension workers, hold the Certificate in Agriculture credential from Lesotho Agricultural College (LAC). This represents 2 years of general agricultural studies with basic instruction in extension methods. Other extension personnel, such as district extension officers, may hold Diplomas in Agriculture from LAC or similar institutions, or may have worked their way up through the system without the benefit of additional formal education. Thus, people with little educational experience are advising farmers. This is not an ideal situation.

Subject matter specialists are also largely district-based. They bear such titles as district crops officer, district livestock officer, and so on. These officers tend to be more specialized than the extension workers. They may hold diplomas from LAC in general or specialized studies, or even the Baccalaureate degree from foreign universities. On the other hand, some may hold the same Certificate in Agriculture as the extension workers they advise, and have acquired their "expertise" through exposure, experience, or short-term participant training. Their principal role is to advise and train extension workers in technical subject matter. Their responsibility is to maintain professional currency in their respective disciplines.

In Lesotho, an extension worker at the village level may provide educational programs for as many as 250 farm families. A subject matter specialist may advise 30 extension workers. These complementary efforts form the fabric of the principal diffusion network in the country.

b. Extension Education Programs

The extension education programs provided by FSR for extension workers fit that type described by Harbison (1973) as "activities oriented primarily to develop the skill and knowledge of members of the labor force who are already employed".

By whatever name, the extension education opportunities provided for this clientele during 1982-1984 were based on systematic needs assessments and were designed to strengthen the professional currency of field officers.

(1) "Extension for Improvement of Farming Systems" Course

Introduction. In terms of extension training and staff development, it became quickly apparent that the most fertile ground was among the extension personnel already in the countryside. These 142 personnel were deployed throughout the 10 administrative districts. Professional levels at MOA Headquarters included director, advisor, chief extension officer, and senior extension officer. In the field, the professional levels were district extension officer, area extension officer, and extension assistant. They were all supported by subject matter specialists who were then members of other MOA technical divisions.

Development and Implementation. The development phase of the proposed training had two parts, development of a course syllabus, and recruitment of trainees.

An extension training course was developed for a 15-day schedule for mid-level extension workers, namely area extension officers and research extension assistants. Research extension personnel traveled to each district to secure commitments from DAOs and DEOs to the process of trainee selection. Thirty-one top candidates were designated as trainees. Units of subject matter course content were assigned to the best resource people available. All invitations to instruct were accepted without exception. The final syllabus was duplicated and distributed, and periodic follow-up was done.

For 11 days in February 1982, 31 area extension officers and research extension assistants received instruction in extension for the improvement of farming systems. Instruction exceeded 80 hours and included both extension methods and agricultural subjects.

Evaluation. A comprehensive evaluation instrument was devised and administered on the final day of the course. The participants shared their impressions and assigned values to the many components and to the training. Personal and group progress, as well as learning acquired was rated medium-to-high. The trainers, along with training aids and techniques were judged medium-to-high as well. Comparison to other training received was high. Comments on course content were favorable, but pointed up need for more practicals to balance out theoretical instruction and mentioned the time constraint. The way trainers organized, planned, and conducted the course left

participants satisfied and motivated. This initial extension education program for district-based personnel was thus executed and evaluated through the first four evidence levels of inputs, activities, people involvement, and reactions as described in Bennett (1980).

(2) "Professional Improvement in Agricultural Extension" Course

Introduction. The training of district extension officers in extension methods and techniques appropriate to developing agriculture and in up-dated technical agricultural subjects was established as a priority need in 1981.

During the training course at Mazenod in February 1982 in "Extension for the Improvement of Farming Systems", the Extension Section of the Research Division was encouraged by the director of extension sevices to include subject matter specialists in the July training. The program joined together the needs of DEOs and SMSs and included one week of intensive training in extension and a second week of technical agriculture instruction for a joint projected audience of 10 DEOs and 20 SMSs. The objective for the course was to enhance the extension skills and agricultural knowledge of DEOs and SMSs.

Top quality lecturers from outside the Division augmented the capability of research personnel. Course development included the expertise of a Washingtom State University consultant.

Implementation. The course on "Professional Improvement in Agricultural Extension" in July 1982 was attended by 5 district extension officers and 25 subject matter specialists from all ten districts.

Basic extension instruction included the following units: philosophy of extension, program development cycle, your agricultural career, effective listening, communication skills, extension management, the farming systems approach, cultural implications for extension, culture and values, needs assessment, writing extension objectives, demonstrations and field trips, motivation skills, lay leadership, training and visit system, interrelationships in agriculture, organizing effective pitsos, the role of village agricultural committees, and program evaluation. Technical agriculture units included were farm machinery, marketing, forestry, agronomy, plant protection, horticulture, soil consevation, animal science, and range science (Matobo 1982).

Evaluation. An evaluation of the workshop was carried out since the organizers and coordinators of the workshop were interested in evaluating a number of key factors. These factors were:

- overall quality of the workshop,
- importance of workshop material to the participants,
- usefulness of workshop material to participants,
- overall effectiveness of the lectures,
- effectiveness of teaching techniques,

- lecturer effectiveness in helping participants learn,
- effectiveness of small group activity,
- effectiveness of visual aids,
- effectiveness of handouts and,
- participants' perception of the benefit of such training to other extension workers.

Conference organizers fixed the criterion for success for each factor studied at 70%. In other words, if 70% of the responses fell at or above the satisfactory level, then the criterion for success had been met. The course was a success as judged by the participants in terms of all the significant factors. There was relatively little difference between the factors of extension and subject matter.

(3) Plant and Soil Science Subject Matter Specialists Training Course

Background. The Extension Division of MOA assessed productivity of field workers and their needs. Then personnel from both Research Division and Extension Division of the MOA began to jointly plan training events which would address identified needs of subject matter specialists on a national basis.

Research Division/FSR was requested to give a mid-1983 short course for plant and soil science subject matter specialists. The Research Extension Section was asked to provide the leadership and organizational expertise for this effort in cooperation with Extension, Conservation, and Crops Divisions, along with logistical support from LAC.

August 1983 was selected as the most appropriate time for the course. Extension Division personnel continued to assist research extension people in the course design and instructional strategies. Research Division was called on to provide most of the instructional faculty, although both Crops and Conservation accepted and delivered two key lecturers. The faculty was composed of both national and expatriate professionals.

Twenty-seven subject matter specialists from all 10 districts in Lesotho attended the course. Most were holders of the Diploma in Agriculture, although a few were Certificate people; 23 participants were men, and 4 were women.

Curriculum. Lectures were delivered by agronomy, horticulture, extension, soils, farm management, and marketing personnel from the Research Division, and by members on the Crops, Extension, and Conservations Divisions.

Evaluation. The Extension Section in the Research Division designed and administered an evaluation, and analyzed the data.

Seventeen participants found the lectures good, 19 felt that the discussion periods were most valuable, and 14 judged the instruction (in whatever form) excellent. Participants expressed their values on topics taught. Horticulture (19) and soil fertility (17) were clearly favorites, while extension (11) and agronomy (11) were also favorably received. Soil conservation (6) and weed control (6) drew good response, and farm machinery (5), marketing (5) and farm management (5) sustained mild interest.

Most participants felt that an SMS course should be 2 weeks, with practicals, and expressed a continuing need for training on a declining scale as follows: agronomy (8), soil fertility (8), horticulture (5), extension (4), farm machinery (4), soil conservation (3), weed control (2), marketing (2), fodder production (2), and farm management (1). Some participants wanted similar training to be conducted on a district level and others wanted to learn methods of approaching the extension assistants with SMS assistance.

The course seems to have demonstrated strength of both content and delivery. There were some weaknesses that need to be corrected or avoided. There was a clear indication of materials to be included in subsequent courses along with some good suggestions on instructional strategy (Youmans, 1983).

(4) "The Extension Challenge": A Course in Extension Methodology

Introduction. After the evaluation of extension and subject matter specialist training, a needs assessment was carried out country-wide during August and September 1983 in order to determine the need for district-based training in extension methods and practitioner skills. The needs assessment was also useful in determining the areas in extension methodology of greatest concern to field-based extension workers and subject matter specialists. Positive responses were collected from Maseru, Mohale's Hoek, Berea, Butha Buthe, Qacha's Nek, Thaba Tseka, and Leribe districts, and it was decided that RD/FSR would undertake such training on a national scale. The scheme was presented to MOA and approved by the director of technical services. It was approved by all district agricultural officers. Three-day sessions were held in each of 10 districts from November 1983 through April 1984.

The traveling faculty included the director of research, deputy director of research, research extension officer, expatriate extension specialist, research extension technical officer, research extension assistant, and research livestock officer. Two officers from Agricultural Information Services were invited to participate at their own expense. The curriculum was developed to contain instruction on:

- relation of research to extension,
- needs assessment techniques,
- group process and dynamics,
- organization and maintenance of farmer contact groups,
- communication skills,
- extension teaching methods,

- visual aids,
- motivation, and
- evaluation.

Implementation. In November, the schools were launched and, by April, had been conducted in all 10 districts, the first nationwide program of its kind. A total of 272 extension workers and subject matter specialists were trained. The Extension Section then conducted an eleventh school with 20 students for National Family Planning and addressed the issues of:

- group process and dynamics,
- role of the field educator,
- the communications process, and
- the importance of reporting.

Evaluation. The field extension workers were asked to identify the strengths and weaknesses of the school, if subject matter was relevant, and how future schools could be improved (Table III-J-6).

These results show a strong interest by the extension field workers in becoming more effective in meeting the needs of their clientele. The five strengths of the school most often cited dealt with improving personal capabilities and programs. In contrast, only 4% considered the segment on the relation of research to extension a strong point of the schools. The fact that 90% of all participants completed a list of strengths indicates the high level of interest.

Thirty percent of the extension workers felt the schools' duration was too short, 31% indicated the school had no weakness, 6% thought the lectures too long, but 137 responses (48.4%) indicated that the school addressed matters of real concern to them and their programs.

Table III-J-6. Strengths of extension schools.

Strength	Response percentage[1]
Needs assessment techniques	28
Extension teaching methods	26
Communication skills	23
Motivation skills	22
Group process and dynamics	18
Effective listening techniques	12
Contact groups	11
Audio/visual aids	11
Relation of research to extension	4

1. Percentage is based on number of responses (283). Each participant was allowed to identify more than one strength. Source: Youmans et al., 1985.

A second phase of the evaluation was designed to determine what extension methods field workers preferred in working with people in their districts. This was done by having them select in order of preference 5 of 21 extension methods (Table III-J-7).

Participants chose farm and home visits as their favorite method of transferring information. It was ranked in the top 5 of 21 choices by 91% of the agents and 62% placed it first. The second choice in that category, informal contacts, was placed in the top 5 by 13% of the respondents. Overall, group contacts were preferred to either

Table III-J-7. Summary of respondents' preference of Extension methods, Lesotho, 1986.

Methods	Ranking (%)[1]				
	1	2	3	4	5
Individual					
Farm and home visits	62	9	9	6	5
Office calls	0	5	1	3	3
Telephone calls	0	0	1	0	0
Personal letters	--[2]	3	3	1	2
Informal contacts	1	4	1	4	3
Group					
Meetings	14	22	8	6	4
Demonstrations	9	22	24	9	6
Tours, field trips	2	4	9	11	8
Group discussions	3	14	11	11	6
Extension schools	--[2]	4	2	5	6
Farmer training centers	0	1	3	7	5
Mass					
Posters	1	4	7	5	7
Exhibits	1	1	4	7	11
Newspapers	0	1	2	2	4
Wall newspapers	--[2]	--[2]	0	2	2
Folders, leaflets, pamphlets	0	0	1	2	1
Fact sheets	0	0	1	--[2]	1
Projected visuals	1	--[2]	0	--[2]	3
Radio	4	6	9	12	17
Television	--[2]	0	0	1	0
Campaigns	0	--[2]	5	5	8

1. Percentage based on total number of respondents, 272.
2. Less than 0.5% (1 person) preferred this method.

Source: Youmans, et al, 1985.

individual or mass media approaches. Use of demonstration was the most popular group contact method.

Summary and Conclusions. Extension and other district-based personnel needed and responded positively to a program of continuing education. High levels of attendance and evaluative response were experienced. The similarity of evaluative responses from all districts regardless of population or location was notable. The schools seem to have been valuable in terms of overall continuing education needs of the ministry as borne out by the comments about improvements for the program. Those constructively critical remarks provided a valuable information base for planning subsequent educational experiences (Youmans et al., 1985).

c. Evaluation of Programs by the RAP Method

The above programs were adequately evaluated at the time through the first four evidence levels of inputs, activities, people involvement, and reactions, as per Bennett (1980). There was a need to further ascertain the impacts of these extension education programs at the upper three evidence levels--a need to know the changes in the KASA realm (knowledge, attitudes, skills and aspirations), in professional practice, and in end results which occurred among extension workers and subject matter specialists as a result of having participated in the FSR extension education programs. The reflective appraisal of program (RAP) methodology as described by Bennett (1982) was used in this investigation.

(1) Data Collection

Critical to the RAP methodology is the design and use of the data collection instrument. Consistent with methodological guidelines by Bennett (1982), four questionnaires were developed in order to secure data of KASA along with practice change and end results evidence levels from participants in all four courses described earlier. These were the Mazenod, Airport, RD/LAC courses, and the 10 district-based extension schools.

The program to be evaluated was briefly described and the purpose of the interview explained to each interviewee. A set of biographical data was collected. Inputs and people involvement were briefly reviewed. The content of each course was included to refresh recall and a validation of content included. A reaction question was asked along with a methods preference question. Essentially, this initial part of the questionnaire was designed to verify, validate, and reconfirm information generally known about the extension education programs.

Standardized but modifiable questions were asked on the content of each program in order to determine changes in KASA, practice, and end results perceived by participants as outcomes of the programs. In all cases standardized responses were followed up by probe questions designed to clarify, verify, or challenge the initial responses.

Finally, recommendations for the improvement of the programs were asked of each respondent.

All participants in the Mazenod, Airport, and RD/LAC courses were targeted for interviews, along with a sample of 67 from the 272 full-time participants in the district-based extension schools. Of the 31 participants in the Mazenod course, 21 returned completed questionnaires, as did 20 of 30 participants in the Airport course, and 18 of the 27 full-time participants in the RD/LAC course. And of the target sample of 67 participants in the district-based schools, 47 completed questionnaires.

The outcomes of the four separate courses were assessed both individually and collectively. Biographical data were examined collectively to assemble a general profile of field staff. Information at the inputs, people involvement, and reactions levels was analyzed collectively to draw some general deductions from that exercise. Activities were analyzed separately for KASA and practice change findings since the audiences, course content, and expected outcomes were different. Examples of practice change and recommendations were grouped since variability was not expected among the outcomes of the four courses. End results were not compiled.

(2) Results

Biographical Data. Of the 15 questions asked, four were selected for further description. They were sex, age, length of ministry service, and level of formal agricultural education.

Of the 106 respondents from all four courses, 74 (70%) were men and 32 (30%) were women. The mean age for male participants was 40, while the mean age for females was 31. Male participants reported a mean of 14.7 years of service with the Ministry, while females reported 7.2 years. Mean years of service for the total sample was 12 years (Table J-8).

Table III-J-8. Years of service with MOA of participants in extension continuing education courses.

Years with MOA	% of total
2-5	22
6-9	25
10-13	13
14-17	6
18-21	18
22-25	8
26-29	7

Of the 106 respondents in the four samples, 71 (67%) hold the Certificate in Agriculture, and 33 (31%) have the Diploma in Agriculture (or in a specialized field).

Validation of Course Content. Among the 106 total respondents, 54 (51%) said the course content description was accurate and 47 persons (44%) said it was reasonably accurate.

The people were asked to what extent the course met their expectations at the time. A majority of 69 respondents (65%) said the course had met their expectations to a great extent. A second group of 28 (26%) reported that they had done so to a fair extent.

(3) Extension Education Methods

The 47 respondents to the district-based "The Extension Challenge" course were not asked to rate extension continuing education methods since their course employed but a single method, the illustrated lecture. However, the other 59 respondents were asked to rate their personal preferences among illustrated lectures, demonstrations, field trips, group discussions, and audio-visual aids. The illustrated lecture was preferred by 26 respondents (44%), demonstrations by 14 (24%), and field trips by 13 people (22%). Four respondents (7%) chose audio-visual aids, and a single respondent (2%) preferred group discussions.

(4) KASA and Practice Change for the Mazenod Course

KASA Change. There is a great deal of variability in the KASA responses of this sample, indicating a discriminating and demanding clientele. The scores indicate generally that most respondents reported KASA gains to a great or fair extent.

Very high KASA responses were reported by the Mazenod course clientele in such subjects as communication skills, motivation, extension in Lesotho, village agricultural committees, and teaching agriculture, while relatively few high responses were recorded for such instructional areas as farm management, program development cycle, and marketing. Moderately high responses were seen for a wide variety of topics including cultural constraints, lay leadership, agronomy, farming systems research, and the extension organization.

It should to be remembered that these scores relate to the relative gains made by participants in their knowledge, attitudes, skills, and aspirations in the 18 topics taught.

Practice Change. There was much more variability in amounts of practice change for this same group as compared to KASA change with respondents indicating "fair" amounts of change in the greater number of cases (Table III-J-9). Fewer practice changes were reported as "great" were less dramatic, and moderate levels of "slight", "don't know" and "none" responses were seen. This was expected since

Table III-J-9. KASA and practice change scores for extension and subject matter specialists in percentage for the Mazenod course, Lesotho 1986.

Topic[1] number	Knowledge[2] 3	2	1	X	0	Attitude 3	2	1	X	0	Skills 3	2	1	X	0	Aspirations 3	2	1	X	0	Practice change 3	2	1	X	0
1	57	39	5	5	0	48	43	5	5	0	43	38	14	5	0	57	38	0	5	0	33	48	14	5	0
2	43	29	19	10	0	29	52	10	10	0	33	43	14	5	5	62	14	14	5	5	19	62	5	5	10
3	48	33	10	10	0	24	48	14	10	5	29	43	19	10	0	33	43	14	10	0	38	38	14	10	0
4	48	43	5	5	0	52	43	0	5	0	33	52	10	5	0	57	33	5	5	0	38	48	10	5	0
5	67	19	5	10	0	62	29	0	10	0	57	29	5	10	0	71	10	10	10	0	43	33	14	0	10
6	38	36	19	6	0	43	43	10	5	0	24	52	19	5	0	62	24	10	5	0	24	43	24	5	5
7	33	38	10	19	0	33	38	10	19	0	10	48	24	19	0	33	29	14	19	5	10	43	13	5	24
8	48	36	0	14	0	52	33	0	14	0	43	33	10	14	0	52	33	0	14	0	38	48	0	5	10
9	33	29	33	5	0	38	33	19	5	5	33	24	33	5	5	38	29	24	5	5	24	19	33	10	14
10	29	29	38	5	0	33	38	19	10	0	29	38	19	5	10	38	29	14	10	10	29	24	19	10	19
11	81	19	0	0	0	81	19	0	0	0	81	14	5	0	0	71	24	5	0	0	62	29	5	0	5
12	24	24	19	33	0	29	38	0	33	0	24	33	10	33	0	19	38	10	33	0	19	24	24	14	19
13	52	29	5	14	0	62	19	5	14	0	48	38	0	14	0	67	14	5	14	0	43	38	5	10	5
14	57	29	5	10	0	62	24	5	10	0	52	38	0	10	0	57	29	5	10	0	33	48	5	5	10
15	48	29	10	14	0	52	24	10	14	0	48	29	10	14	0	52	29	5	14	0	29	33	24	10	5
16	19	48	19	14	0	33	38	14	14	0	29	43	14	14	0	38	29	19	14	0	29	38	24	10	10
17	29	24	29	19	0	19	33	24	24	0	14	33	33	19	0	19	29	29	19	5	14	24	24	10	29
18	33	24	24	5	10	52	19	14	10	5	19	38	29	5	10	24	38	24	5	10	10	38	33	5	14

1. Topics: 1. Extension in Lesotho, 2. Your organization, 3. Cultural constraints, 4. Lay leadership, 5. Motivation, 6. Program evaluation, 7. Appropriate technology, 8. Agronomy, 9. Soils, 10. Forestry, 11. Communication skills, 12. Program development cycle, 13. Teaching agriculture, 14. Village agricultural committees, 15. Farming systems research methods, 16. Farm mangement, 17. Marketing, 18. Range Ecology.

2. Responses: (3) to a great extent, (2) to a fair extent, (3) to a slight extent, (X) don't know/don't recall, (0) none at all.

practice change is known to be more difficult to achieve than gains in KASA.

Ninety-one and 81% of the respondents reported practice changes in communications skills and extension organization in the "great" or "fair" categories. Moderate change was reported in extension, lay leadership, agronomy, teaching agriculture, and village agricultural committee work. Low change levels occurred in forestry, program development, and marketing.

(5) KASA and Practice Change for the Airport Hotel Course

KASA Change. There was considerable variablility in KASA change responses to agricultural subjects with reports of "fair" levels of change being frequent (Tables III-J-10). The highest percentage of "3" scores was recorded for farm machinery, farming systems research, range science, and marketing. The bulk of the "2" scores were related to animal science, horticulture, agronomy, plant protection, and animal diseases. Consistent "1" scores were registered for agronomy, farm machinery, forestry, plant protection, soils and conservation, and range science. There was slight "x" (no recall) scoring in all subjects. The highest levels of negligable KASA change in agricultural subject matters were seen in farm machinery, forestry, soils, range, and animal diseases.

KASA change scores for extension subject matter were also variable with "fair" reponses again being quite frequent (Table III-J-11). Topics such as motivation, communication skills, effective pitsos, demonstrations and field trips, and program evaluation were consistently given high marks. Philosophy of extension and agricultural careers and related topics received many "2" or fair responses. A rather normal array of KASA change levels was found. No recall seemed to be a modest but persistent problem with instruction in extension management and logistics in extension.

Practice Change. Practice change in agriculture ensuing from the Airport Hotel extension education course was highly variable (Tables III-J-10 and III-J-11). The highest level of "great" practice change was in horticulture. This was overshadowed by many reports of "fair" practice change in agronomy, animal science, horticulture, farming systems research, and range science. Significant numbers of respondents reported "slight" levels of practice change in agronomy, farm machinery, plant protection, marketing, and soils and conservation. The highest levels of no recall were found in marketing and range science, and rather high levels of negligible practice change in animal diseases, soils and conservation, range science, and marketing.

There was considerable variability in responses to practice change in extension topics, although "3" and "2" scores seemed to prevail in most subjects taught (Tables III-J-10 and III-J-11). Practice change to a great extent was the trend in such areas as writing extension objectives, training and visit system, village

agricultural committees, communications skills, needs assessment, demonstrations and field trips, and effective pitsos. Practice change to a fair extent was reported after instruction in philosophy of extension, effective listening, extension management, motivation skills, interrelationship in agriculture, program development cycle, agricultural careers, logistics in extension, and program evaluation. Slight practice change was significant for cultural implications, interrelationships in agriculture, needs assessment, and in lay leadership. Modest no recall was seen for interrelationships in agriculture and program development cycle, while no practice change was only significant in the training and visit scheme.

(6) KASA and Practice Change for Research Division (RD/LAC) Course

KASA Change. The plant and soil science subject matter specialists reported KASA changes occurred to "a great extent" potato production, weed control, extension methods, horticulture, farm machinery, soil sampling techniques, marketing and communications (Table III-J-12). Fair KASA change "2" scores prevailed in agronomy and farm management. Slight change "1" scores dominated only in soil conservation, while the only significant no recall was in farm management. Very slight negligible KASA change was seen for fodder production.

Practice Change. Practice change was also quite positive. Between 40% and 60% of the respondents reported significant practice change in agronomy, potato production, weed control, extension methods, horticulture, and communications. Moderate amounts of practice change were reported by 50% in extension methods. Slight practice change was significant only in soil conservation, while the largest no recall score was in farm management (27%). Negligible practice change predominated for soil sampling techniques and was also significant in weed control and soil conservation (Table III-J-12).

(7) KASA and Practice Change for District-Based Course

KASA Change. Scores of "3" indicating KASA change to a great extent dominated in all components of KASA and for all subjects. KASA change to a fair extent was also significant for all subjects. Slight KASA change was seen in relation of research to extension and visual aids in the skills and aspirations components, while no recall was significant only for needs assessment (Table III-J-13). The number of responses indicating no KASA change was insignificant.

Practice Change. Practice change reported by this group differed slightly from KASA scores in that fair change tended to predominate in needs assessment relation of research to extension, group formation and dynamics, and extension teaching methods. Practice change to a great extent prevailed in communications skills and visual aids, while slight change was significant in needs assessment and visual aids (Table III-J-13). Negligible practice change was insignificant while a significant no recall response was seen for extension teaching methods.

Table III-J-10. Total KASA and practice change responses in percentages by participants in the Airport Hotel extension course, agriculture topics.

Topic[1] number	Knowledge[2]					Attitude					Skills					Aspirations					Practice change				
	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0
26	7	5	3	3	2	5	6	2	4	3	4	4	6	4	2	5	1	7	4	3	3	4	5	4	5
19	9	7	3	1	0	9	10	0	1	0	6	9	3	1	1	6	8	4	1	1	6	8	3	2	1
2	5	7	5	1	2	6	8	4	0	2	2	11	3	2	2	3	12	3	0	2	2	9	6	1	2
15	7	10	2	0	1	6	11	2	0	1	7	8	4	0	1	7	9	3	0	1	7	7	4	0	2
29	8	2	5	2	3	8	3	5	1	3	6	3	6	1	4	6	5	5	1	3	3	7	4	1	5
14	3	11	3	0	3	8	6	4	0	2	3	8	5	0	4	6	7	5	0	2	2	7	4	1	6
27	6	6	3	2	3	5	8	2	1	4	4	6	4	1	5	5	6	3	1	5	4	4	6	1	5
11	9	2	5	0	4	7	5	4	0	4	6	6	5	0	3	6	6	4	0	4	5	4	5	0	6
30	6	6	3	1	4	7	4	2	1	3	4	6	3	3	4	4	8	3	1	4	3	5	3	2	7
13	5	8	6	0	1	6	10	3	0	1	5	6	6	0	3	5	9	4	0	2	5	5	5	1	4
28	6	5	5	1	3	5	6	4	2	3	2	8	4	2	4	3	7	4	2	4	2	4	6	2	6
12	4	4	6	2	4	6	2	6	2	4	5	3	6	2	4	5	4	4	2	5	5	3	4	2	6

1. Subjects: 2. Agronomy in Lesotho, 11. Farm machinery, 12. Forestry, 13. Plant protection, 14. Animal science, 15. Horticulture trips, 19. Farming systems research, 26. Marketing, 27. Agronomy, 28. Soils and conservation, 29. Rance science, 30. Animal diseases.

2. Responses: (3) to a great extent, (2) to a fair extent, (3) to a slight extent, (X) don't know/don't recall, (0) none at all.

Table III-J-11. Total KASA and practice change responses in percentages by participants in the Airport Hotel extension course, extension topics.

Topic[1] number	Knowledge[2]					Attitude					Skills					Aspirations					Practice change				
	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0
16	8	7	3	2	0	8	4	5	3	0	5	6	6	3	0	6	6	4	4	0	4	8	2	4	2
22	5	7	4	3	1	4	6	5	3	2	4	7	4	3	2	4	5	7	3	1	5	4	6	2	3
23	13	4	2	1	0	10	5	3	0	2	9	7	3	1	0	8	8	3	0	1	8	7	3	0	2
9	8	7	5	0	0	11	5	3	1	0	9	7	3	1	0	7	8	4	1	0	10	4	5	1	0
24	5	8	3	4	0	5	6	3	4	2	4	8	3	4	1	5	7	3	4	1	4	8	3	3	2
17	7	7	2	3	1	11	6	1	1	1	6	8	2	3	1	6	10	2	1	1	6	7	3	3	1
25	11	7	2	0	0	9	9	1	0	1	6	10	2	0	0	11	7	2	0	0	6	9	4	0	0
8	7	4	5	1	3	6	3	5	1	3	7	3	5	1	4	8	5	4	1	2	7	3	4	1	5
7	18	2	5	0	0	11	5	4	0	0	7	5	7	1	0	9	8	3	0	0	7	8	5	0	0
21	10	6	3	0	1	13	4	3	0	0	9	6	3	0	2	10	5	2	0	1	8	7	3	0	2
6	10	6	3	0	1	10	6	4	0	0	6	10	4	0	0	6	10	4	0	0	9	5	5	0	1
1	6	10	2	2	0	7	11	0	2	0	0	13	4	3	0	4	12	1	3	0	4	9	5	1	1
5	3	6	9	2	0	4	5	9	2	0	2	5	11	2	0	3	4	10	2	1	2	6	7	3	2
20	10	5	3	2	0	8	6	4	2	0	7	6	5	2	0	10	3	5	2	0	9	2	7	1	1
18	14	5	1	0	0	12	7	1	0	0	8	9	3	0	0	9	9	2	0	0	10	7	3	0	0
10	5	9	2	3	1	5	7	4	3	1	4	7	4	3	2	6	5	4	3	2	1	7	6	4	2
4	7	7	2	4	0	6	10	0	3	1	4	9	3	4	0	5	11	0	3	1	2	10	4	3	1
3	7	13	0	0	0	11	7	2	0	0	8	9	3	0	0	5	13	2	0	0	7	8	5	0	0

1. Subjects: 1. Philosophy of extension, 3. Effective listening, 4. Extension management, 5. Cultural implications, 6. Writing extension objectives, 7. Motivation skills, 8. Training and visit scheme, 9. Village agricultural committees, 10. Interrelationships in agriculture, 16. Program development cycle, 17. Your agricultural career, 18. Communication skills, 20. Needs assessment, 21. Demonstrations and field, 22. Lay leadership, 23. Effective pitsos, 24. Logistics in extension, 25. Program evaluation.

2. Responses: (3) to a great extent, (2) to a fair extent, (3) to a slight extent, (X) don't know/don't recall, (0) none at all.

Table III-J-12. KASA and practice change (in percentages) in the Research Division extension education course, Lesotho.

Topic number[1]	Knowledge[2]					Attitude					Skills					Aspirations					Practice change				
	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0
1	39	44	11	0	6	61	33	0	0	6	28	33	22	0	17	50	33	11	0	6	56	17	17	0	11
2	61	22	17	0	0	72	22	6	0	0	50	33	11	6	0	67	33	0	0	0	61	17	17	0	6
3	22	22	33	17	6	39	22	22	17	0	17	28	28	17	11	33	28	28	11	0	17	28	22	11	22
4	67	17	11	6	0	94	6	0	0	0	56	33	6	6	0	72	17	6	6	0	44	17	6	6	28
5	22	33	11	28	6	28	28	11	26	6	17	39	11	28	6	28	39	6	22	6	22	22	17	28	11
6	61	39	0	0	0	61	33	0	0	6	61	39	0	0	0	56	33	6	0	6	44	50	6	0	0
7	78	17	6	0	0	72	22	0	0	6	72	11	11	6	0	72	28	0	0	0	56	28	11	0	6
8	50	17	28	6	0	44	33	17	6	0	44	17	28	6	6	50	22	17	6	6	44	17	22	6	11
9	56	28	11	6	0	61	28	6	6	0	39	28	22	6	6	61	22	11	6	0	28	17	0	6	50
10	28	17	28	17	11	39	33	6	17	6	28	33	6	17	17	33	28	17	17	6	33	22	11	17	17
11	39	22	22	17	0	44	17	22	17	0	33	28	22	17	0	28	28	28	17	0	22	28	17	17	17
12	72	28	0	0	0	72	28	0	0	0	61	22	17	0	0	61	22	11	0	6	56	28	17	0	0

1. Topics: 1. Agronomy, 2. Potato production, 3. Soil/conservation, 4. Weed control, 5. Farm management, 6. Extension methods, 7. Horticulture, 8. Farm machinery, 9. Soil sampling, 10. Fodder production, 11. Marketing, 12. Communications.

2. Responses: (3) to a great extent, (2) to a fair extent, (1) to a slight extent, (X) don't know/don't recall, (0) none at all.

Table III-J-13. KASA and practice change among participants in the district-based extension education course in percentages, Lesotho, 1986.

Topic[1] number	Knowledge[2]					Attitude					Skills					Aspirations					Practice change				
	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0	3	2	1	X	0
1	38	38	13	11	0	47	34	9	11	0	36	32	21	11	0	36	23	26	13	2	15	38	19	9	19
2	38	32	15	15	0	45	32	6	15	2	38	38	6	15	2	45	26	13	15	2	21	40	23	6	9
3	47	32	13	9	0	57	28	4	11	0	38	36	11	11	4	45	40	2	11	2	23	47	15	6	9
4	64	26	6	2	2	64	21	13	2	0	49	38	11	2	0	49	34	15	2	0	48	30	19	0	9
5	55	15	19	11	0	57	15	15	6	6	34	32	21	6	6	47	17	21	6	9	21	28	17	2	32
6	57	36	2	4	0	60	34	2	4	0	49	32	15	4	0	45	30	21	4	0	38	28	26	2	6

1. Topics: 1. Relation of research to extension, 2. Needs assessment, 3. Group formation and dynamics, 4. Communication skills, 5. Extension teaching methods, 6. Visual aids.

2. Responses: (3) to a great extent, (2) to a fair extent, (1) to a slight extent, (X) don't know/don't recall, (0) none at all.

(8) Examples of Practice Change Among Extension Workers

Open-end probe questions were asked of participants in the extension education courses conducted for district-based extension workers and subject matter specialists, permitting them the opportunity to expand on their responses. Examples of practice changes are described follow.

Respondent DB-4 formed a farmers' association of 35 members in order to purchase inputs on credit and contract for tractors, to which over half contributed financial quotas. Respondent DB-5 surveyed sites and gathered farmer opinion on location of irrigation sites, organized crop production associations, and conducted monthly training for district staff employing improved extension methods. Respondent DB-7 made his own visual aids. Respondent DB-8 organized ox-drawn implement groups, involving 90 farmers, for plowing and planting operations. Respondent DB-15 began to make farm and home visits to her women's groups after attending the course. Respondent DB-17 used posters to demonstrate proper weeding. Respondent DB-26 said his improved communication skills and extension techniques were used in his work with TOU farmers. Respondent DB-29 sent soil samples to the research laboratory, and practiced group techniques among his farmers.

Respondent DB-30 used the village agricultural committee method with good results. Respondent DB-33 used charts and posters in nutrition education and measuring tapes for demonstration of field size. Respondent DB-34 taught animal nutrition to his farmers. Respondent DB-37 organized a Merino association of 17 farmers who have purchased 350 improved ewes and 10 rams, and a Brown Swiss association of 35 farmers who intend to work toward improved animal quality. Respondent DB-38 used visual aids to demonstrate functional poultry houses to farmers who are now building their own. Respondent DB-40 taught farmers about the advantages of using cow manure and also demonstrated intercropping using beans and peas with maize. Respondent DB-41 read research circulars which were helpful to his work.

Respondent DB-44 said she formed a village agricultural committee, and is using posters in her extension programs. Respondent DB-46 conducted a planting demonstration on cabbage for members of young farmers' clubs, took them on farm walks, and used visual aids to show breed characteristics of swine and dairy cows. Respondent DB-47 developed charts and posters about food groups and breast-feeding. Respondent RD-2 used cultivars applicable to his region and conducted some market research. Respondent RD-3 did some physical and chemical weed control. Respondent RD-4 made use of the farm machinery mobile unit in her area. Respondent RD-5 planted grass for donga control. Respondent RD-6 implemented an apple tree program with 95 farmers. Respondent RD-7 conducted short courses on the calibration of ox-drawn machinery. Respondent RD-11 taught farmers how to mulch and encouraged them to plant trees. Respondent RD-3 devised farm

management instruction for an illiterate farmer group. Respondent RD-14 encouraged farmers to grow fodder on marginal lands. Respondent RD-15 ordered FAO-funded weeding machinery for farmers.

Respondent M-2 organized pitsos for instruction in sorghum production. Respondent M-7 mounted agricultural campaigns using farmers as deliverers of the campaign messages; he also planted pine and poplar trees. Respondent M-8 tried to improve maize production through on-farm trials. Respondent M-9 taught farmers about hybrid seed. Respondent M-10 planted a woodlot with villagers over a 2-week period. Respondent M-11 facilitated market contracts for farmers among both villagers and traders. Respondent M-12 conducted wheat variety trials with four different farmers on the highveld. Respondent M-19 implemented a rotational grazing program in his area.

Respondent AH-2 was able to recognize animal diseases and relate them to appropriate treatments. Respondent AH-3 conducted program evaluations. Respondent AH-4 staked tomatoes with maize. Respondent AH-6 promoted supplementary feeding of livestock. Respondent AH-7 formed wool and mohair growers groups. Respondent AH-14 adopted methods taught about organizing effective pitsos with good results. Respondent AH-15 organized in-service training for subordinates around discussion groups. Respondent AH-17 did research in afforestation in the mountain area. Respondent AH-18 helped extension assistants use short format to plan annual work programs. Respondent AH-19 motivated farmers to improve indigenous cattle.

This review of examples of practice change reflects the substantial array of subject matter contained in the extension education programs conducted for this clientele, indicates its practical nature, and demonstrates the manner in which innovations learned were put into practice by agricultural professionals in the field.

(9) Recommendations by Participants

Respondents gave the following recommendations when asked what suggestions they had to improve the Research Division's continuing education programs:

- continuing education courses with greater frequency (38, 36%)
- more practicals (29, 27%)
- more follow-up research (24, 23%)
- courses should be longer (2 weeks as opposed to 1 week) (19, 18%)
- field trips are necessary (14, 13%)
- lecturers should be more knowledgeable and more audio-visual aids should be used (11, 10%)
- more time per topic and nutrition education to be included as a subject matter (10, 9%).

d. Summary

The impacts of Farming Systems Research extension continuing education programs for field-based extension workers and subject matter specialists were both positive and significant. It was valuable to take those programs, which were restricted, to the districts in order to reach more field people and to get closer to field problems.

Instruction in extension education methods strengthened the professional versatility of persons earlier trained in technical subject matter, while instruction in agriculture increased the knowledge and skills of general extension workers. In both cases, the "up-date" nature of the programs was most appropriate.

KASA change related to the programs was impressive, in one course dramatic. Although there was considerable variability in responses, changes to a great or fair extent were most frequently seen. Change to a slight extent was also significant. Cases of no recall and no learning were isolated to infrequent instances for very few subjects.

Practice change responses were variable but positive. Many respondents reported practice change to a fair or great extent in areas of specialization or particular appropriateness. No practice change and no recall were less frequently reported and seemed to be related to subjects not relevant to the respondent's principal assignment or simply of little interest to him/her.

Examples of practice change were encouraging in that they represented testimony to the feasibility of sound extension education events under conditions of limited resources. Under those circumstances, associated reports of inhibiting factors seemed to articulate complaints rather than constraints. Important recommendations were compiled by participants which tended to support and improve the current trend of extension continuing education programs.

The executive summary of this section is on pages 90-94. The summary of accomplishments and recommendations is on page 99.

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