UNIVERSITY OF THE FREE STATE

SOCIO-ECONOMIC COMPLEXITIES OF SMALLHOLDER RESOURCE-POOR RUMINANT LIVESTOCK PRODUCTION SYSTEMS IN SUB-SAHARAN AFRICA

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A thesis submitted in partial fulfillment for the degree of Doctor of Philosophy

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This dissertation is dedicated

to the

African smallholder farmers,

particularly women

"Africa would not be able to produce a surplus above current consumption levels, nor would it lay the foundation for sustainable development, if African farmers are not sufficiently empowered to use productivity techniques of their choice in producing what they think is profitable" (Deng et al., 1995).

I declare that this thesis hereby submitted for the degree of Doctor of Philosophy at the University of the Free State, is my own dependent work, and has not been submitted for degree purposes to any other university. I hereby forfeit any copyright of this thesis to the University of the Free State.

Ek verklaar dat die proefskrif wat hierby vir die graad Doktorandus van Filosofie aan die Universiteit van die Vrystaat deur my ingedien word, selfstandige werk is en nie voorheen deur my vir 'n graad aan 'n ander universiteit ingedien is nie. Ek doen voorts afstand van die outeursreg van die proefskrif ten gunste van die Universiteit van die Vrystaat.

……………………………………..
Aldo Stroebel

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LIST OF ACRONYMS

AAAP	Asian-Australasian Society of Animal Production
AEZ	Agro-ecological Zone
AFTES	French Association for Underground Works
ALARPM	Action Learning Action Research and Process Management
ASAL	Arid and Semi-arid Land
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATNESA	Animal Traction Network for Eastern and Southern Africa
BASED	Broadening Agricultural Services and Extension Delivery Project
BW	Body weight
CAST	Center for Applied Special Technology
CETRAD	Centre for Training and Integrated Research for ASAL Development
CH_4	Methane
CIDA	Canadian International Development Agency
CO_2	Carbon Dioxide
CRSP	Collaborative Research Support Programme
CTA	Technical Centre for Agricultural and Rural Cooperation
CYMMIT	International Center for Wheat and Maize Improvement
DBSA	Development Bank of Southern Africa
DFID	Department for International Development
DoA	Department of Agriculture
DSE	Foundation for International Development (Germany)
EPTD	Environment and Production Technology Division
ESP	Environmental Support Programme
EU	European Union
FAO	Food and Agricultural Organisation
FAO-SAFR	FAO-Subregional Office for Africa
FCND	Food Consumption and Nutrition Division
FSP	Farmer Support Programme
FSR	Farming Systems Research
FSR&D	Farming Systems Research and Development
FSR&E	Farming Systems Research and Extension
GCIS	Government Communication and Information Service
GDP	Gross Domestic Product
GPS	Global Positioning System
GTZ	German Technical Cooperation
HDRA	Henry Doubleday Research Association
IARC	International Agricultural Research Centre
IBAR	Inter-African Bureau for Animal Resources
ICPTV	Control of Pathogenic Trypanosomes and their Vectors
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Council
IDS	Institute of Development Studies
IFAD	International Fund and Agricultural Development
IFPRI	International Food Policy Research Institute

IIED	International Institute for Economic Development
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
INRA	International Institute for Agronomic Research
ISRIC	International Soil and Reference Information Centre
IUCN	World Conservation Union
JACS	Joint Areas of Case Studies
KARI	Kenya Agricultural Research Institute
KSAS	Korean Society of Animal Science
LID	Livestock in Development
LR	Livestock Revolution
MIT	Massachusetts Institute of Technology
MoA	Ministry of Agriculture
MSU	Michigan State University
NARP	National Agricultural Research Programme
NARS	National Agricultural Research Systems
NERPO	National Emerging Red Meat Producers' Organisation
NGO	Non-governmental Organisation
NO_2	Nitrogen Dioxide
NSF	National Science Foundation
NUTNET	Nutrition Network
O_3	Ozone
OAU	Organisation for African Unity
ODC	Organisation for Development Cooperation
ODI	Overseas Development Institute
PAR	Participatory Action Research
PPLPI	Pro-Poor Livestock Policy Initiative
PRA	Participatory Rural Appraisal
RPO	Red Meat Producers' Organisation
SADC	Southern African Development Community
SANAT	South African Network of Animal Traction
SAS	Statistical Analysis System
SE	Standard Error
SIDA	Swedish International Development Agency
SLM	Sustainable Land Management
TLU	Total Livestock Units
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States of America
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WAAP	World Association of Animal Production
WRI	World Resources Institute

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CHAPTER 1

INTRODUCTION

This introductory chapter discusses the background of the study and considers the research motivation and objectives. This is followed by an outline of the subsequent chapters of the thesis.

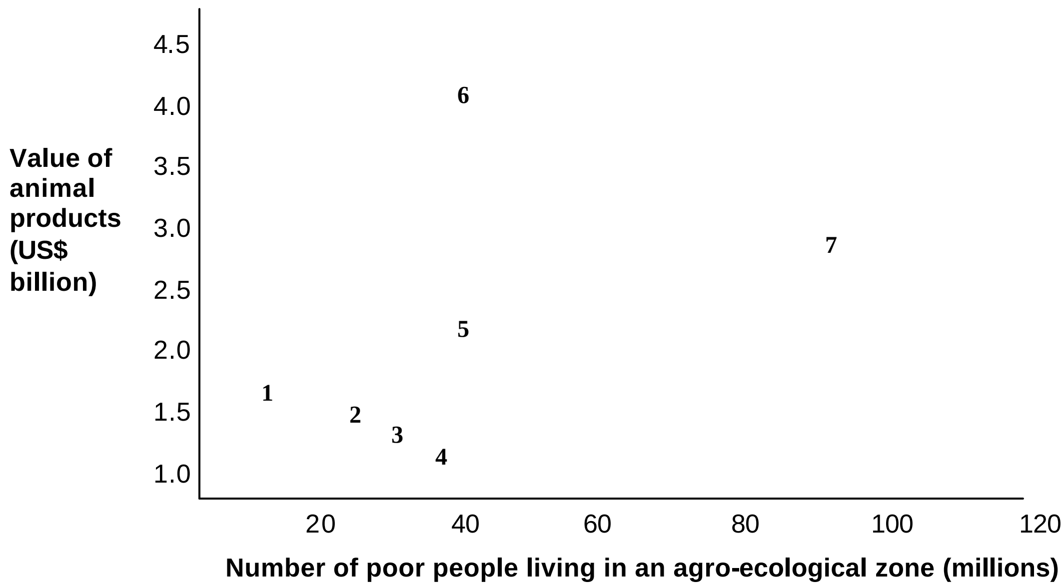
1.1 Research Motivation

The challenge to overcome hunger remains one of the most serious confrontations facing humanity today. The threat of starvation is most serious in Africa, where an estimated 33% (138 million) of the population, mainly women and children, suffer from malnutrition (FAO, 2000). More than 1.3 billion people, representing one third of the population of the developing world, live below the poverty line (defined as an income of less that US$1 per day). The situation is worst in Sub-Saharan Africa where more than 50% of the people fall into this category. The percentage of the population below US$1 a day is highest in Zambia at 85% and Uganda at 69%, with Kenya at 50% and South Africa at 24% (IFAD, 2002). In Mali, 91% of the population live below US$2 per day (FAO, 2003). Recent statistics estimate that there are more than one billion poor people in rural areas of developing countries. Of these, an estimated 680 million people, representing about two thirds of the rural poor, keep livestock, confirming the importance of livestock to their livelihoods (LID, 1999). This further emphasises the recent focus on pro-poor strategies in livestock development projects (Stroebel and Swanepoel, 2004)**.** Recent statistics reveal that an estimated 70% of the poor are women for whom livestock play an important role in maintaining status and often represent their most valuable asset and provide an important source of income (DFID, 2000).

A recent analysis indicates that by far the largest number of poor people in the developing world live in regions where mixed farming systems predominate so that these integrated crop-livestock systems provide livelihoods to most of the rural poor

(ILRI, 2000). Focusing research on improving the sustainable livelihoods of people in mixed farming systems can do more to reduce poverty than increasing productivity in intensive, industrialised systems (LID, 1999).

In Figure 1.1, the relation between the value of animal products and the number of poor people by agro-ecological zone for Sub-Saharan Africa is shown:



1 *grassland, temperate and tropical highlands*

2 *grassland, humid/ subhumid tropics and subtropics (rainfed and irrigated)*

3 *mixed temperate and tropical highlands (rainfed and irrigated)*

4 *industrial (monogastric and ruminants)*

5 *mixed arid/ semi-arid tropics and subtropics (rainfed and irrigated)*

6 *grassland, arid and semi-arid tropics and subtropics (rainfed and irrigated)*

7 *mixed humid/ subhumid tropics and subtropics (rainfed and irrigated)*

Figure 1.1 Value of Animal Products from Major Livestock Production Systems and the Number of Poor People in the Different Agro-Ecological Zones (AEZ) of Sub-Saharan Africa (adapted from ILRI, 2000)

As can be seen from Figure 1.1, around 40 million rural poor are involved in the arid and semi-arid grassland livestock production systems of the tropics and subtropics of Sub-Saharan Africa. For instance, the average value of the animal products they produce is almost US$3.2 billion (AEZ five and six). Given the large number of people and land area devoted to these systems in Southern and Eastern Africa, they are an appropriate focus of this study.

Livestock, particularly ruminants, provide households with a number of benefits, as presented in Table 1.1. From an environmental perspective, livestock can contribute significantly towards sustainability in well-balanced, mixed farming systems (de Haan et al., 1997). Apart from the benefits listed in Table 1.1, owning ruminants encourages smallholders to plant browse trees, grass, shrubs and legumes, all of which can control erosion, promote water conservation and increase soil fertility.

Table 1.1 A Summary of Benefits and Products Derived from Livestock (Pell, 1999; Swanepoel et al., 2000)

Benefit	Products
Food	Milk; meat; eggs; blood; fish; honey; processed products.
Clothing	Wool; hides; skins; leather.
Work	Draft power – cultivation; transport of goods and people; threshing; milling; pumping water.
Monetary	Capital wealth; investment; savings account; income from: hiring working animals; sale of products; sale of animals.
Social	Lobola (bride price); ceremonial; companionship; recreational; status.
Manure	Fertiliser (soil amendment); fuel; flooring.
Other benefits	Feathers; bone meal; soap production.

Livestock production frequently conflicts with conservation of wild animals and biodiversity due to competition for feed and water, transmission of disease and predation (Voeten, 1999). However, if farmers understood how wildlife can use alternative forage species and how they can contribute to the sustainable use of marginal land, the farmers would make better informed and more appropriate decisions on conservation and animal and plant biodiversity.

Modest increases in the consumption of meat and milk will improve the nutritional status of the poor, by providing the protein, vitamins and micro-nutrients that are currently deficient (Neumann et al., 2002; Reid et al., 2002).

Figure 1.2 presents a comparison of meat and milk consumption in the developed and developing worlds. Over the next 20 years, there will be a massive increase in the demand for food of animal origin, with virtually all the increased demand coming from developing countries (Delgado et al., 1999). Although there are important regional differences, the rate of increase in demand for livestock products will be high in the densely populated areas of Sub-Saharan Africa (with the highest rate of

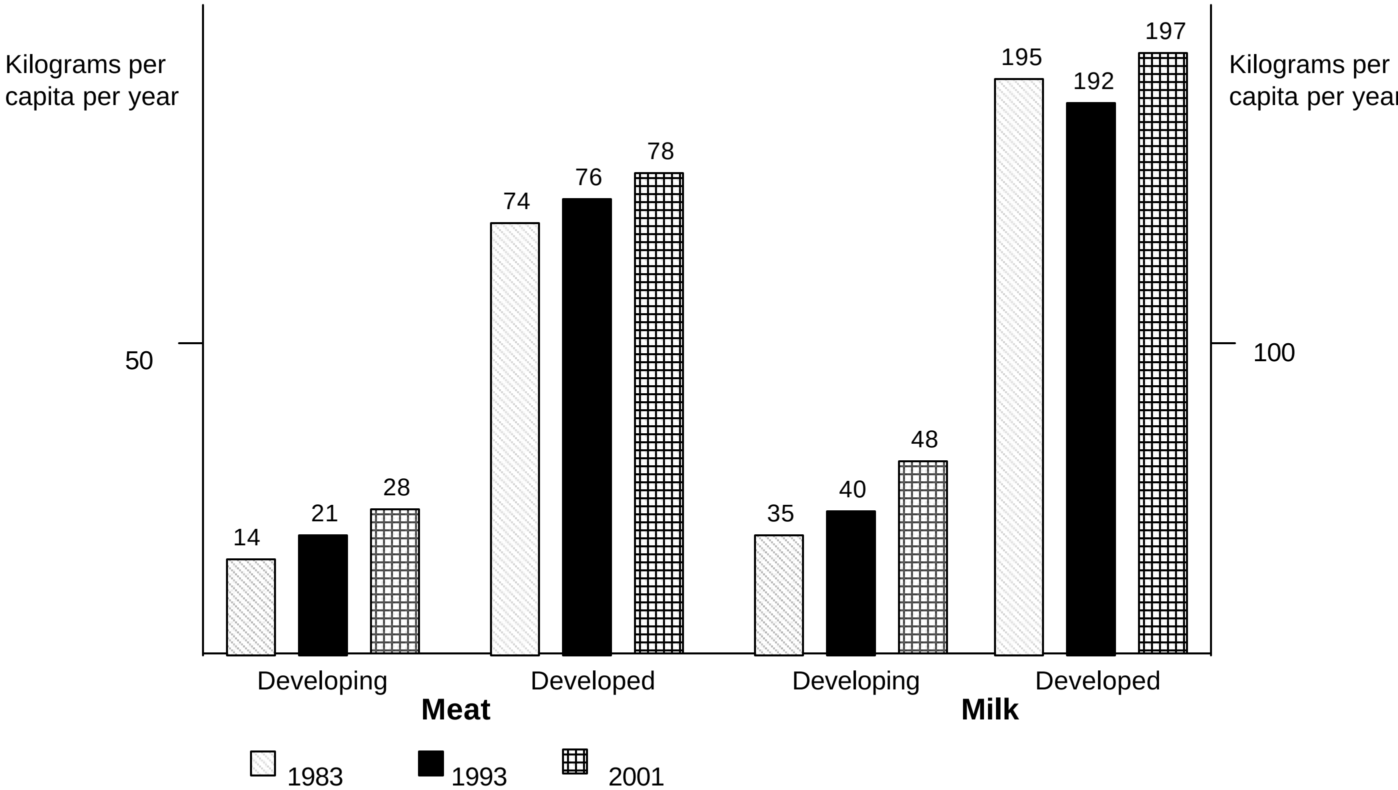


Figure 1.2 Per Capita Consumption of Meat and Milk in Developing and Developed Countries: 1983, 1993 and 2001 (adapted from ILRI, 2000; FAOStat, 2004)

consumption in China). Increasing urbanisation, which will result in more than half of the population of developing countries living in towns and cities by 2020, and growth in income levels, will drive this demand. The magnitude and significance of the projected increases in demand for livestock products in developing countries over the next 20 years have been coined the "Livestock Revolution" (Delgado et al., 1999). The implications, opportunities and challenges represented by the Livestock Revolution are considered by some to be just as great as those that accompanied the Green Revolution of the 1970s (ILRI, 2000; Evenson and Gollin, 2003). Increased production of meat in Sub-Saharan Africa will continue to come primarily from cattle, sheep, goats and increasingly, from poultry. Ruminants will be reared either on rangelands, especially in arid and semi-arid areas, or in mixed farming systems in higher potential areas.

Cousins (1988) rightly stated that a full understanding of the role of livestock in the economies of rural Africa remains one of the most challenging problems confronting researchers, development planners and practitioners. This is supported by the classic quote from Little (1980): "…there are few development issues today which entail a greater complexity of sociological, economic and ecological variables than that of livestock development in Sub-Saharan Africa". This is still very valid today, and justifies the focus of this study on ruminant livestock production systems in Eastern and Southern Africa.

In Figure 1.3, a general model for the livestock system, placed in the wider context of the farming system and its biophysical and socio-economic environments, is presented:

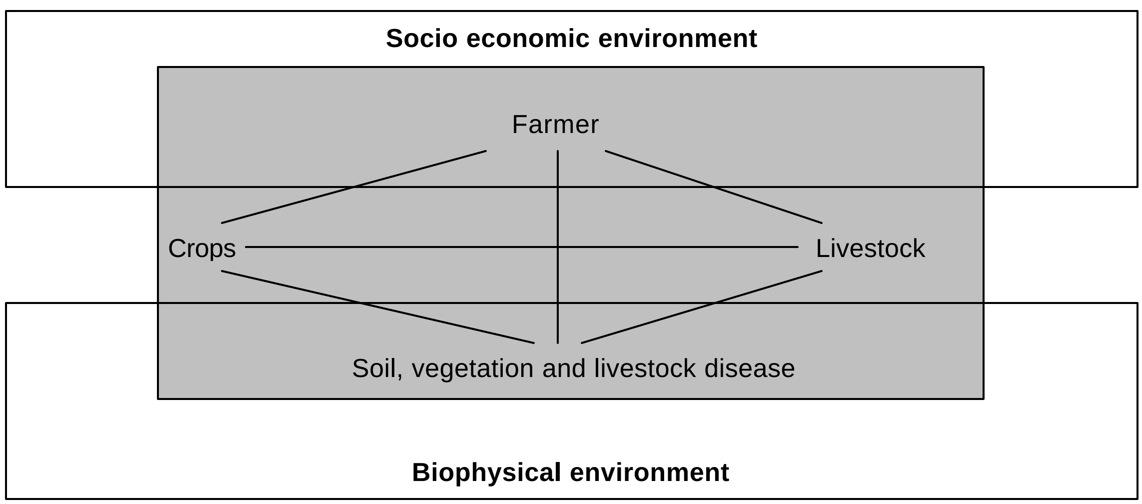


Figure 1.3 The Livestock System and its Environment (adapted from Roeleveld and van den Broek, 1996)

Even when presented in its simplest form, it is clear that understanding the livestock system requires more than knowledge of livestock alone. Accordingly, a farming systems approach was selected as the methodology for this study. While biophysical conditions and the genetic make-up of livestock determine potential animal production, the socio-economic and institutional conditions and the farmers' skill and level of decision-making determine which products and production levels will be realised. Understanding a livestock system requires description and analysis of its various components and their functional inter-relationships (the system's functioning), rather than the description of livestock production alone. These relationships are best understood by analysing the various flows among system components and by analysing farmers' management decisions.

1.2 Research Objectives

For the purpose of this study, the objectives were categorised into descriptive, theoretical and applied objectives.

The descriptive objectives were to:

- Portray smallholder livestock farming systems in the Limpopo Province (Nzhelele Area)[1] of South Africa with respect to:
    - Household livelihood indicators such as income and expenditure patterns, resources and assets
    - Household division of labour
    - Productivity measures and herd dynamics of ruminant livestock
    - Effect of seasonality on livestock rearing and productivity
- Portray smallholder livestock farming systems in the Baringo District of Kenya with respect to:
    - General policy environment
    - Main policy constraints inhibiting the development of smallholder farming systems.

The theoretical objectives were to:

- Examine the evolution of farming systems research, specifically in relation to its application in livestock production systems

[1] Herein after referred to as "Nzhelele Area"

- Analyse how livestock farming systems function with specific focus on socio-economic complexities and the challenges of sustainable natural resource management
- Analyse how households function, utilise resources and assets and how livestock contribute to increased food and livelihood security
- Analyse the herd dynamics and productivity measures in relation to food and livelihood security
- Analyse the inter-relational effects of farm size, family size, cultivated area, grazing land area and maize area cultivated
- Identify constraints to increased output from ruminant livestock production
- Identify elements to construct a model for livestock policy development in Kenya and South Africa.

The applied objectives were to:

- Analyse the role of gender in livestock-related activities
- Examine constraints to efficient livestock production
- Examine how livestock production contributes towards food security
- Contribute to the livestock policy development process in Southern and Eastern Africa.

1.3 Outline of the Thesis

Chapter two discusses the research design and methods used in collecting data. It presents an explanation of the sampling procedure, pilot work and the procedure followed to ensure buy-in and ownership by participants. Further, the limitations of the study, the plan for data analysis and the time schedule of the study are presented. It also presents the demographic and socio-economic profiles of the research areas in the two countries, namely the Nzhelele Area in South Africa and the Baringo District in Kenya. A GPS-referenced map of the sample region in the

Nzhelele Area of South Africa as well as an orientation map for the Baringo District in Kenya are included.

Chapter three provides a brief introduction, followed by discussion of the general evolution of Farming Systems Research (FSR), and then presentation of some specific aspects of livestock systems research, including a number of key issues with respect to smallholder livestock production systems.

Chapter four discusses the conceptual and theoretical framework of livestock systems research based on existing literature. The main components are the important role of livestock in smallholder farming systems, the Livestock Revolution (LR), constraints to livestock production systems and gender roles.

Chapter five summarises the environmental impacts of livestock production within the context of sustainable natural resource management. It critically reviews property rights and land tenure systems and grazing (arid- and semi-arid) and mixed farming systems, and concludes with aspects of the impact of livestock on wildlife, its role in greenhouse gas emissions, nutrient recycling and its impact on forests in Sub-Saharan Africa. The conceptual and theoretical framework provided in chapters four and five also present the key variables that guided the direction and design of the study.

Chapter six examines herd dynamics, productivity measures, primary reasons for farming with livestock and crop-animal interactions for smallholder livestock producers in the Nzhelele Area of South Africa.

Chapter seven compares family size, farm size, cultivated area, maize area cultivated, grazing area and livestock production (cattle and goat herds) for smallholder livestock producers in the Nzhelele Area of South Africa.

In Chapter eight, based on analyses of the Baringo District in Kenya and the Nzhelele Area in South Africa, a comparison of policy options and constraints between Eastern and Southern Africa is made. The research focus areas and institutional support required to develop a framework to guide livestock policy development in Eastern and Southern Africa are critically examined.

Chapter nine includes the conclusions of this study.

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CHAPTER 2

RESEARCH DESIGN AND METHODOLOGY

This chapter provides insight into how the research project was conducted. It discusses the research design, orientation stage, methods of data collection and analysis, time schedule of the research project and a description of the two study areas.

2.1 Research Design

The research design was both descriptive and empirical. A combination of quantitative and qualitative research methods were used because they compliment each other (Scrimshaw, 1990; Zhang, 2001). Philosophical foundations, characteristics and techniques can be found in both quantitative and qualitative research, each with its own strengths and weaknesses (Wittenberg and Sterman, 1996). These characteristics make them ideally suited for exploration of some research questions, but they are inadequate for the investigation of others (Forrester, 1994). As Dobberts (1982) points out, all scientific procedures have their weaknesses, because they are designed to do one thing and not others.

Past research has tended to focus exclusively on knowledge production from an analytical-empirical perspective, using traditional quantitative methods associated with the dominant scientific paradigm (Mtshali, 2002). However, a possible integration of research methods, based on either simultaneous or sequential mixing of quantitative and qualitative values and techniques, is perhaps the best avenue to find the answers to questions posed, and being influenced by Farming Systems Research (FSR) (Barrett, 2004).

Validity and reliability, as methodological concepts, are essential for the integration of qualitative and quantitative techniques. Validity can be defined as the degree to which scientific observations measure what they purport to measure. Reliability refers to the replicability or the extent to which the same results are obtained when scientific observations are repeated (Scrimshaw, 1990). Issues of validity and reliability within research are equally important in qualitative and quantitative methods, although they may be treated differently (Narman, 1995). Thus, all research methods have advantages as well as limitations. In this context, the study combined several methods including observation, unstructured and structured interviews with key informants, focus group discussions, a survey and individual interviews. Each method was used to supplement and verify information using triangulation (Giddens, 1993)[3].

Quantitative research was used to address questions that were predominantly based on the descriptive and some theoretical objectives of the study. Examples include herd dynamics and productivity measures of livestock within the farming system in South Africa. In contrast, a more qualitative research framework, such as the policy environment in Kenya, was used to address issues from the theoretical and applied objectives. In addition, this approach was used to collect sensitive data, such as gender roles, income and assets (i.e. herd size). For South Africa, questionnaires were used to quantify data and key informant interviews. Focus group discussions and individual interviews were used to collect qualitative and quantitative information. In Kenya, key informant interviews and literature were used to collect qualitative and quantitative data. In general, research was conducted in three stages: orientation and exploration, confirmation and refinement. Using mixed-method research enabled the triangulation of data and increased analytical power, as each data source assisted in the interpretation of the other (Meinzen-Dick et al., 2003).

The relationships and interactions between the various stages of research, groupings, and different research tools used are illustrated in Figure 2.1:

[3] Refer to chapter three, section 3.5 for this discussion within the context of FSR

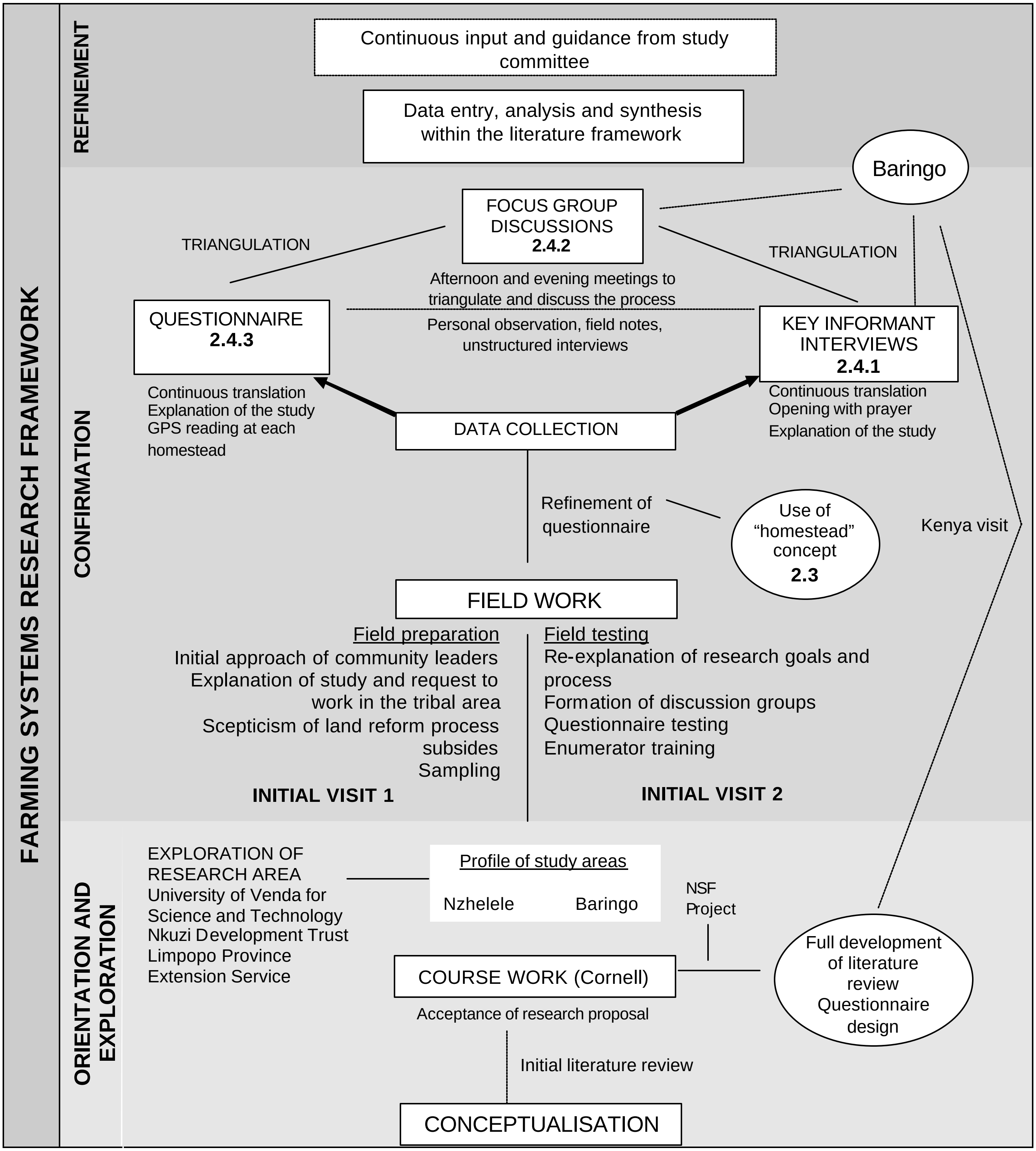

Figure 2.1 Visual Presentation of the Various Components of the Research Process

2.5 Orientation Stage

Following acceptance of the research proposal and the completion of the coursework component[4] at Cornell University, a profile of the communities in the Nzhelele Area was compiled. To facilitate sharing of the study design with the proposed stakeholders, we approached the University of Venda for Science and Technology in the Limpopo Province of South Africa. The University, through Mr Maanda Dagada, organised a number of meetings and discussions to get advice and obtain permission to continue with the study. This included talks with Mr Thomas Madilonga and Mr David Kwinda of Nkuzi Development Association and Mr Alfred Malepfane, the Acting Senior Manager: Vhembe District in the Limpopo Province. The enumerators (researchers at the Centre for Rural Development at University of Venda for Science and Technology), Mr James Mulaudzi, Mr Evens Azwindini Muntswu and Mr Khathutshelo Munyai were involved in this orientation process. At this stage, contacts were also made with the key informants; most notably the Chairpersons of the Village Development Committees (particularly Mr S Maelula, Mr P Maguada, Mr P Mudimeli, Mrs G Managa and Mr ND Ramuntshi). Preliminary community profiles were compiled on the basis of data collected from secondary sources (Swanepoel et al., 2000; 2002; Nthakheni et al., 2003; StatsSA, 2003).

During the stages of field research (refer to Figure 2.1), additional research tools were used to supplement the main instruments employed to collect data. These included a comprehensive literature review, personal observations, field notes and unstructured interviews.

The orientation stage for data collection in Kenya was initiated at Cornell University with the participation in the National Science Foundation (NSF)/Cornell University Biocomplexity Project meetings. The author attended these meetings during the course work component of the study i.e. January to June 2003. During a visit to

[4] The coursework component at Cornell University took place during the period January to June 2003. It was specifically compiled to add value to the study, and to expand and enrich the knowledge of the author in the areas of tropical forages, livestock in tropical farming systems, rural sociology and rural livelihoods and biological resources.

Kenya, unstructured interviews were held with various project personnel, most notably with Mr David Amudavi and Dr David Mbugua, both members of the Cornell University research team based in Kenya and also employees of Egerton University and the Kenyan Agricultural Research Institute (KARI) respectively. Personal observations and field notes were made during attendance at a farmers' workshop in Embu District where the Cornell University research team presented preliminary findings on soil analysis, as well as during a field visit to the Baringo District (the focus of the study), facilitated by Dr Elizabeth Meyerhoff of the Rehabilitation of Arid Environments Charitable Trust. In addition, various interviews and discussions were held with government personnel, extension workers and non-governmental organisation (NGO) representatives in the Baringo District.

A country profile of Kenya was compiled on the basis of data collected from secondary sources (Murithi, 1998; Bhushan, 2002; Amudavi and Mango, 2003; Kisoyan and Amudavi, 2003; KenyaWeb, 2004). A comprehensive literature review of Kenyan smallholder livestock production systems was conducted during this period.

2.6 Unit of Measurement

In this study, it was critical to define an appropriate unit of measurement. The household was initially chosen as the "family" or "core" unit. However, it became clear during the implementation stage that the western concept of *household* in the context of rural Limpopo Province (Nzhelele Area) in South Africa is the *homestead*. It was challenging to define homestead membership, because of complex urban-rural migration patterns. The final unit of analysis was a group of people who were mostly relatives, sharing the same residence (homestead), activities and resources. The operational definition included individuals who shared a residence, ate together, and shared livelihood resources and strategies who may or may not have been related. People were included in this operational definition if they were identified as members of the homestead by the head of the homestead or the person interviewed. No quantitative time frame was used to define membership in the homestead.

This study focuses on the socio-economic complexities of smallholder ruminant livestock production systems. Describing this system requires information on livestock management. To gain this information, the herd was chosen as the most important entity to observe. Therefore, to coincide with the homestead as the *principal management unit*, the herd is the unit of measurement when describing *productivity measures and dynamics*.

As discussed in section 2.4.1, data collection in the Baringo District of Kenya was not based on questionnaires administered to households (or homesteads). It is therefore not based on data obtained from specific “units”, and hence has not been analysed as such. Key informant interviews were used to determine common constraints and coping mechanisms in order to construct a framework to guide livestock development in Eastern and Southern Africa (as discussed in chapter eight). These general trends are based on information from the literature review as well as the outcomes from the interviews.

2.7 Methods of Data Collection

The methods of data collection included completion of the structured questionnaire, unstructured interviews, and observation. Field notes were written and analysed. The following section examines three methods of data collection that were undertaken: key informant interviews, focus group discussions and the homestead surveys in the case of the Nzhelele Area, and key informant interviews and focus group discussions in the case of the Baringo District.

2.4.1 Key Informant Interviews

Valuable and salient information can often be collected from a few members of the community who are knowledgeable about the area. A community survey, in the case of the Nzhelele Area, was undertaken to collect data from key informants through individual interviews. Groups from the ten villages in this study area were formed, consisting invariably of the chief of the village, and representatives of women, youth and elders. The chief of each village was approached to explain the study in detail. He was requested to form groups of village members on a random basis, with the necessary spatial distribution of homesteads. The names of the identified group members were submitted in writing to verify that there were not too many family members of the Chief (as this could introduce bias as to the information that they may provide), as well as to ensure that homesteads were not clustered too closely to each other. In addition, it was important to compile the groups with the necessary representation of women, youth and elders. Each group included between seven and 11 members. Between two and three key informants were informally selected from each group by the research team. Care was taken to ensure that other members of the group did not feel that their contribution was not important. These same groups were used in the focus group discussions as explained in section 2.4.2. In addition, extension officers in the areas were interviewed as key informants.

Through key informant interviews, underlying nuances and confidential information often are revealed that does not occur when other research methods are used. Members interviewed spoke freely of local incidents, conditions and underlying constraints to the community. In addition, the interview setting allowed flexibility to explore new and unanticipated issues which were relevant to the study. The disadvantage of this method is that it is often difficult to determine whether the respondents are knowledgeable, adequately informed or accurately reflect the opinions of the group(s) they are representing. The information of the key informants was very helpful, but to confirm the information and views obtained from the key informants, focus group discussions were crucial.

Due to the general nature of the data collection in Baringo District, key informant interviews were the only source of first-hand data. Those interviewed were selected based on knowledge of livestock systems and policy issues in Kenya. In addition, an experienced extension officer was recruited to provide detailed information on the Baringo District.

2.4.2 Focus Group Discussions

Focus group discussions were used in the Nzhelele Area to obtain additional perspectives and to validate information from the key informant interviews. These discussions permitted the development of more focused themes for further study in the questionnaire, which was used as the formal survey instrument for the study. With the assistance of the enumerators, Village Committee Chairpersons and local extension staff, groups from the ten villages in the study area were selected. For the most part, people who participated in the key informant interviews were not included in the focus group discussions. This allowed the groups to discuss their views freely, uncompromised by influences from participants in the key informant interviews. The enumerators formed part of each focus group discussion to translate discussions directly into *Tshivenda*, the local language. Reimbursement for transport was offered to those who made use of public transport.

The following topics were included in the discussion guide:

- Homestead characteristics and farmers' knowledge
- Farming experience
- Farm information
- Production and management information
- Natural resource and environmental issues
- Production risk reduction
- Marketing management
- Economic viability
- Social acceptability of farming and personal outlook.

The focus group discussions took place at the homesteads of the community leaders or in the usual meeting places of the different villages. The participants were informed of what was required both in terms of content and process, and the amount of time needed. Detailed notes were made by the enumerators and by the researcher. These were later compared and discussed to ensure that all issues raised had been recorded. The issues for discussion were introduced and participation by all was encouraged. On average, the focus group discussions lasted two to three hours each.

2.4.3 Structured Questionnaires

A structured questionnaire, with open- and close-ended questions, was used to survey the identified homesteads in the Nzhelele Area. The questionnaire was compiled based on profiles of earlier studies in the area and on previous research (Grosh and Glewwe, 1990). Members of 189 homesteads were interviewed from ten nearby villages. These were: Maelula (24), Vuvha (42), Ratombo (37), Mudimeli (37), Maangani (six), Mamuhohi (18), Mandiwana (five), Dolidoli (16), Dzanani (three) and Migavhini (one).

Early in the survey, scepticism on the part of the respondents about the purpose of the survey became apparent. Land reform and redistribution are underway in this area as mandated by the national government of South Africa. As a result, it was difficult to get access to some villages. These issues were resolved after intervention by the well-connected local extension service. They clarified that the survey was independent of the land reform process.

During the pilot phase, the enumerators tested the questionnaire and issues regarding time, type of questions and the process were raised. Respondents were reluctant to answer questions about income, savings, number of cattle owned and organisations which they were members of. These questions were rephrased to ensure that dependable and appropriate data would be elicited from the respondents. In addition, consistency questions were added to validate the responses. A revised version of the questionnaire is attached as annexure two.

Face-to-face interviews were conducted during administration of the questionnaire. The enumerators were to interview the head, or the *de facto* head, of each homestead. If such a person was not available during the scheduled interview, a follow-up appointment was made. In a cluster of homesteads in a village, every third homestead was included in the sample. If it was not possible to include the third homestead in the sample, the next homestead was used as a substitute. Some homestead representatives refused to be interviewed, either because a financial incentive was not provided or because of misinformation about the purpose of the study (sensitivity regarding the land reform process). If, after careful explanation, the homestead representative still was not willing to participate, the next homestead was chosen. From the sample of 189 homesteads, 86 had livestock. This sub-sample was used to analyse herd dynamics and production (chapter six) and the influence of farm and family size on crop and livestock (cattle herds and goat flocks) production (chapter seven) in the Nzhelele Area.

The latitude and longitude readings at the centre of each homestead were recorded using a Geographical Positioning System (GPS); model Garmin GPS II+®. The centre of the homestead refers to the entrance of the primary building or the closest to that entrance. A list of GPS coordinates for each household is attached as annexure three.

2.4.4 Sampling

A nonprobability sampling method was used to select a sample for the homestead survey (Byerlee and Collinson, 1984). The method of selection was based on the judgement of the researcher, with valuable input from the collaborating institutions and other local resources. The selection of the sample was purposive, as it was assumed that most of the homesteads in the selected villages were typical, based on previous studies in the area. Nkuzi Development Association, a local South African NGO, provided useful insight into the local population distribution and homesteads from which the sample was drawn. The selection of the villages was based on willingness to participate and to ensure an adequate sample size of homesteads. In addition, the villages formed part of a predetermined area to evaluate the effectiveness of farming methodologies after land appropriation. As mentioned in section 2.4.3, scepticism regarding the land reform issue was adequately addressed, as the objective of the study is to characterise smallholder ruminant livestock production in the area to improve livelihoods, and not to investigate a homestead's eligibility for land or their right to it. The results of this study will therefore feed into a future study, but is unbiased towards the objectives of that study.

2.5 Data Analysis

Data from the completed questionnaires were entered by Mr James Mulaudzi, one of the study enumerators and a graduate of the University of Venda for Science and Technology. Analyses were completed with the assistance of a statistician at the University of the Free State. The data analysis in chapter six was performed using Statistical Analysis Systems (SAS) (SAS, 1990), and direct calculations. Analyses of data included herd size and composition, reproduction, herd mortality and offtake, main reasons for farming and crop-animal interactions. To examine the existence and magnitude of associations between farm resources and livestock data in chapter seven, partial correlation analysis and analysis of variance were completed (SAS, 1990). The statistical model for the analysis of data on cattle herd size and goat flock size (dependent variables) included the main effects of family size, farm size, grazing land area, cultivated area and maize area cultivated (independent variables) (Raubenheimer, 2005). For the analysis of data on cultivated area and maize area cultivated, homesteads were characterised as small or large farms. This differentiation was based on the size of the cattle or goat herds kept, i.e. cattle herd size and goat flock size, as well as all other variables, including family size and farm size, is categorized as *large* when they were larger than the respective means and *small* when they were smaller or equal to their respective means. Cattle and goat herd sizes were described in terms of animal numbers, because of the general uniformity in size of the animals. Although this might be inconsistent due to size differences between mature and young animals, similar studies have used the number of animals, arguing that the young stock and mature animals are more or less equal in numbers, and therefore balances out (Gryseels, 1988; Moroosi, 1999; Widi et al., 2004).

The GPS readings were plotted against an electronic map of the survey area to assess the distribution of the homesteads. This methodology provided valuable information about access to natural resources, movement networks between homesteads, markets and other resources and spatial variation of cattle ownership. In addition, referencing the study area in this way provides the opportunity for other researchers to conduct additional studies in the same area. A map of South Africa, with the extracted study area, indicating the GPS referenced homesteads, is included in section 2.7.3 of this chapter. An orientation map of Kenya, with the Baringo District indicated, is included under section 2.7.5 of this chapter.

2.6 Time Schedule of the Research

This study was undertaken during a three-year period from 2002 to 2004. Much of the planning and background reading was conducted in early 2002, with the literature review initiated during this period. The project proposal was finalised and accepted during the second half of 2002. This was followed by a semester of course work at Cornell University from January to June 2003. The period from June to December 2003 was devoted full-time to field work, including key informant interviews, focus group discussions and individual interviews in the Nzhelele Area in South Africa and key informant interviews and literature reviews in the Baringo District in Kenya. Data entry and analysis took place during the period October 2003 to June 2004, when the first draft was submitted. The period July – September 2004 was spent re-analysing and revising the thesis, based on input from the study committee.

2.7 The Study Areas

This section discusses the study areas. It provides a brief overview of the countries of South Africa and Kenya, followed by discussions of the study areas (Nzhelele Area and the Baringo District).

2.7.1 South Africa

The Republic of South Africa is at the southern-most tip of the continent of Africa, located latitudinally between 22^0 to 35^0 S and longitudinally between 17^0 to 33^0 E. It has a surface area of 1,2 million km^2 and is surrounded by the Atlantic Ocean to the west and the Indian Ocean to the south and east. South Africa borders Namibia, Botswana, Zimbabwe, Mozambique and the small Kingdom of Swaziland. The Kingdom of Lesotho is a land locked country entirely located within the borders of South Africa (GCIS, 2003).

Before 1989, the government upheld white minority rule, whereby Africans, Indians and Coloureds were discriminated against under the *apartheid* system. Under this system, only 14% of land was set aside for Africans in ten "homelands" allocated for 44% of the population (Nel and Binns, 2000). The largest of these areas were Transkei, Bophuthatswana, Venda and Ciskei. These homelands were not recognised as independent countries by other nations and relied on the Government of South Africa for all matters regarding state and internal affairs (Stroebel, 2001). Following the first democratic elections in 1994, the former homelands were reintegrated into South Africa and nine new provinces were delineated: Northern Cape, Western Cape, Limpopo, KwaZulu-Natal, Eastern Cape, Mpumalanga, Gauteng, Free State and North West. However, as a legacy of the country's history, the economy is still largely controlled by whites, with a largely non-white labour force.

According to Census figures, 79% of the population is African, nine percent Coloured, 2,5% Indian or Asian and ten percent White. The total population of South Africa is estimated at 45 million people (StatsSA, 2003).

The topography and surrounding oceans influence the climate of South Africa, and temperatures as high as 32^0C are common between December and February. The average annual rainfall is 464 mm, compared to a world average of 857 mm. As can be seen in Table 2.1, this amount is regarded as the absolute minimum for successful dryland farming in South Africa. Periodically, the country is affected by wide-spread and prolonged droughts, which often end in severe floods (M'Marete, 2003).

Table 2.1 Bioclimatology of South Africa (adapted from Dennis and Nell, 2002)

Climatic zone	Area (%)	Annual Rainfall (mm)
Arid	50	<500
Semi-arid	40	500-750
Sub-humid	10	>750

Agriculture, forestry and tourism are an integral part of the economy of the country. The major crops include maize and other grains, vegetables, peanuts, deciduous and citrus fruit, cotton, tobacco and sugarcane. The agricultural sector generated five percent of the gross domestic product (GDP) in 2000, while approximately 16% of economically active people are employed in agriculture (Stroebel, 2001).

2.7.2 The Limpopo Province

The Limpopo Province of South Africa is located in the northern-most part of the country. Previously known as the Northern Province, it is bordered by Zimbabwe to the north, Mozambique to the east, Botswana to the west and the provinces of Gauteng, Mpumalanga and North West to the south. It comprises a surface area of 124 000 km^2 (10% of the land area of the country) and is the fifth largest province in South Africa in size, and the fourth largest in terms of population (5,6 million people).

Under the apartheid government of South Africa, the Limpopo Province had three homeland areas: Lebowa for the Sothos, Gazankulu for the Shangaans and Venda for the Vendas. People were forced to live in the homelands based on their ethnicity. Overcrowding in these former homelands led to soil erosion and the development of slums, with residents having almost no possibility of paid employment. Of the total population of 5,6 million people, 97.2% are African, 0.2% are Coloured, 0.1% are Indian and 2.6% are White.

Statistically, the Limpopo Province is the poorest province in South Africa, with the lowest per capita income and the highest number of illiterate people (StatsSA, 2003). The province is the most rural in South Africa with 89% of its residents residing in rural areas. The unemployment rate is high at 46% (StatsSA, 2003).

The geography, rainfall and soil fertility are varied. Agriculture is the main source of income, with maize as the primary staple crop. Cattle farming predominate in the arid and semi-arid western and northern parts. Livestock and livestock-related products account for more than 50% of the agricultural income of the province (Oni et al., 2003). Smallholder, resource-poor mixed farming is the most prevalent agricultural system. Large scale, commercial farming enterprises, mostly owned by white farmers, produce most of the agricultural goods in the province. Smallholder farms are usually located in the former homelands and cover approximately 30% of the province. These farms are characterised by low levels of productivity and small farm holdings of approximately 1.5 ha per farmer. Production is primarily for subsistence purposes with little marketable surplus (Oni et al., 2003). The agricultural sector in the province is the largest employer outside of government, with approximately 122 000 people living and working on farms.

2.7.3 Nzhelele Area

The study was conducted in the Nzhelele Area in Ward 27 of the Makhado Municipality of the Vhembe District in the eastern part of the Limpopo Province. This area was part of the former Venda homeland. It is located at 23^0 S latitude and 30^0 E longitude, and has an average altitude of 903 m. The area is close to the borders of Zimbabwe and Botswana. Figure 2.2 contains a map of the Limpopo Province of South Africa, with the study area extracted, indicating the GPS-referenced homesteads.

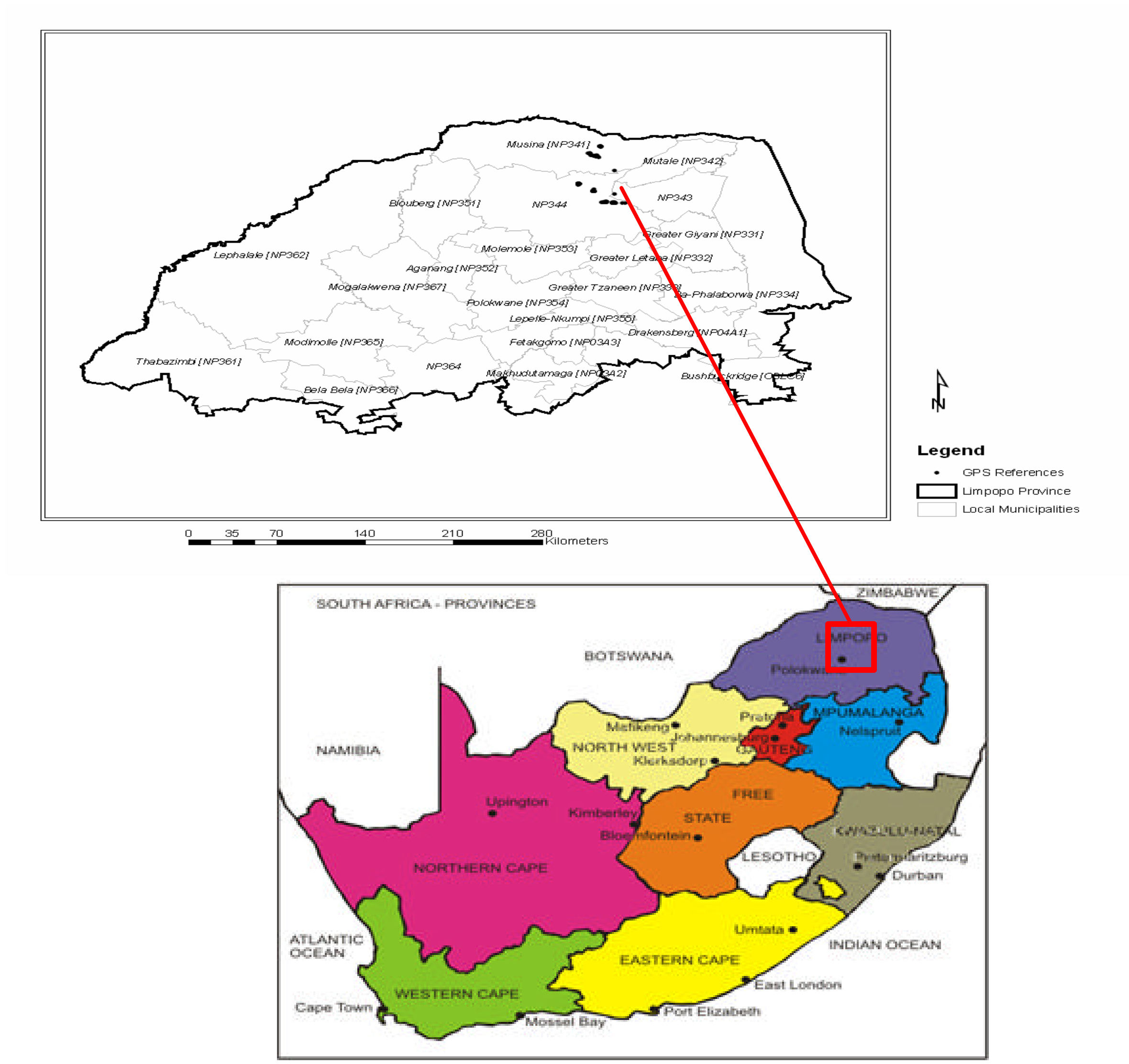

Figure 2.2 **Map of South Africa, with the Study Area Extracted, Indicating the GPS Referenced Homesteads**

The population of the Makhado Municipality is estimated at 500 000 people, of whom approximately 11 300 reside in the Nzhelele Area (StatsSA, 2003). Of this number, almost 90% are African, (StatsSA, 2003). The education level is very low, with more than 26% of the population having less than a complete primary level education (Standard Five/ Grade Seven). Only 15% have completed secondary school training. Of the total labour force, 41% of the population is involved in formal agricultural activities. This statistic does not include informal farming or subsistence farming activities in the area. Almost 56% of the total population have no formal monthly income. The total number of homesteads is 2736, with eleven percent comprising traditional or informal housing (refer to section 2.3 for a discussion of *household* vs.

homestead). For 52% of the homesteads, annual income is less than ZAR 6 000 (US$ 900), with 17% having no formal income.

Average temperatures range between 15^0C and 26^0C. The mean annual precipitation is 780 mm, of which 80% occurs during the summer months (October – March). Livestock and crop farming are the predominant forms of agriculture, with communal cattle farming enterprises comprising approximately 50% of the farming in the area (Acheampong-Boateng et al., 2003). Smallholder farms are located throughout the Nzhelele Area, characterised by low levels of productivity and holdings of approximately 1.5 ha per farmer, although this figure is varied. Production is primarily for subsistence purposes with little marketable surplus.

2.7.4 Kenya

The Republic of Kenya is situated on the coast of East Africa, stretching longitudinally from 4^0 S and 4^0 N, and latitudinally from 34^0 to 42^0 E. It has a surface area of 583 000 km^2 and is bordered by the Indian Ocean, Somalia, Ethiopia, Sudan, Uganda and Tanzania (Bhushan, 2002). The population of Kenya was estimated to be 31 million people in 2001 (Bhushan, 2002).

There are two distinct wet seasons during April to June and October to November. The Coastal Belt and the highlands of the Rift Valley receives up to 1250 mm of rain per year, while many of the lower-lying areas, especially in Western Kenya, receives up to 800 mm per year (Bhushan, 2002). Agriculture is the main earner of foreign exchange for the country, with a 30% share in the GDP, and provides employment to more than 75% of the total labour force. It is the main activity of more than 85% of the rural population (Murithi, 1998). Livestock is one of the most important agricultural activities, accounting for 10% of GDP and 50% of employment in the agricultural sector (Wandera, 1995). The principal Kenyan exports are tea, coffee and horticulture. Tea and coffee are the main cash crops in smallholder agriculture, although it is mostly produced on large, commercial farms. However, in Western

Kenya, tea is a crop that is produced as a last resort only when the soil cannot produce other crops (Pell et al., 2003).

Kenya is classified as a low-income country, with more than 50% of the population living in poverty (less than US$1 per day). Sixty percent of the population is below 25 years of age, with more than 80% of the population living in rural areas.

2.7.5 Baringo District

Baringo is one of the 14 districts in the Rift Valley Province of Kenya. It borders Turkana and Samburu districts to the north, Laikipia to the east, Nakuru and Kericho to the south and Uasin Gishu, Elgeyo Marakwet and Pokot to the west, and is located between longitudes 35^0 30' and 36^0 30' E and latitudes 0^0 10' S and 0^0 140' N. The district covers an area of 10 949 km^2 (Kenyaweb, 2001). Figure 2.3 is a map of Kenya showing the Rift Valley and Baringo District.

It is estimated that Baringo District has a population of 242 000 people, with a high annual average growth rate of three percent (Central Bureau of Statistics and ILRI, 2003). The range of people falling below the Kenyan poverty line of US$ 0.53 per day is between 29% and 73%, for a district mean of 46%. This variation is based on the presence of an irrigation scheme, bringing opportunities of employment and income generating activities, as well as the irregular rainfall, negatively influencing the livelihood of a large part of the population in the area. The district, like the country, has a very youthful population, with 50% falling in the age category 0-14 years. It is estimated that there are 72 000 households, with an average number of five people per household.

Baringo District has an arid to semi-arid climate, with variations depending on the topography. The district is divided into four areas: the upper and lower highlands and upper and lower midlands. Rainfall varies between 600 and 1500 mm, with 50% reliability. Livestock production activities are found in all four areas, but predominantly in the upper and lower midlands (Kenyaweb, 2001). The two major upland and lowland zones have soils that are generally well drained and fertile. Rangelands comprise 70% of the district.

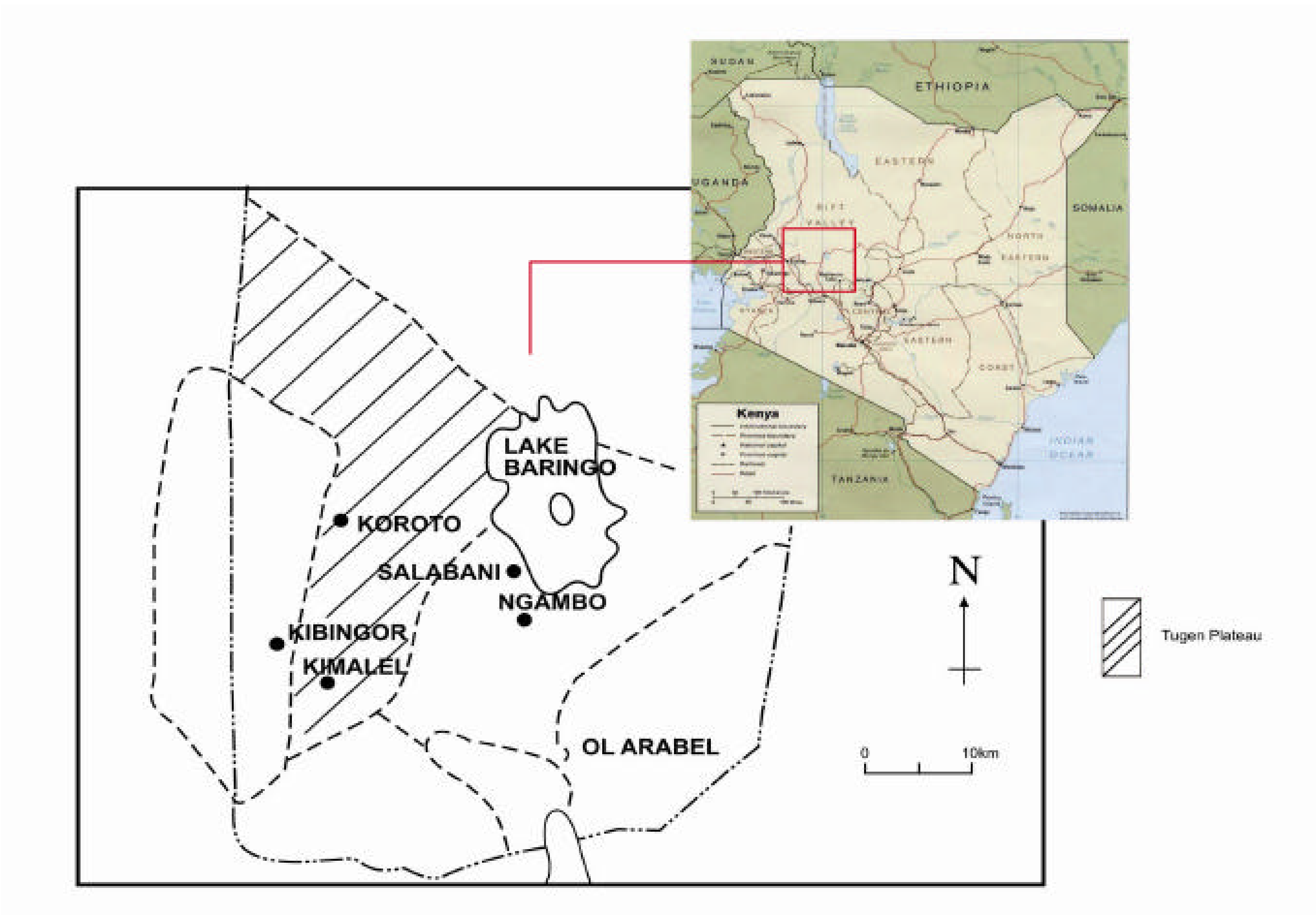

Figure 2.3 Map of Kenya, with the Rift Valley and the Baringo District Indicated

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CHAPTER 3

FARMING SYSTEMS RESEARCH

Abstract

Farms vary in their resource endowments and in the family circumstances of the owners, with various resource flows and external interactions at the farm level. The biophysical, socio-economic and human elements of a farm are interdependent, and can be analysed as a system from various points of view. The challenges experienced in conducting diagnostic livestock studies are often attributed to the specific characteristics of livestock keeping. Taking cognisance of each farmer's unique environment and context is central to the framework of farming systems research.

Keywords: farming systems, livestock, research

3.1 Introduction

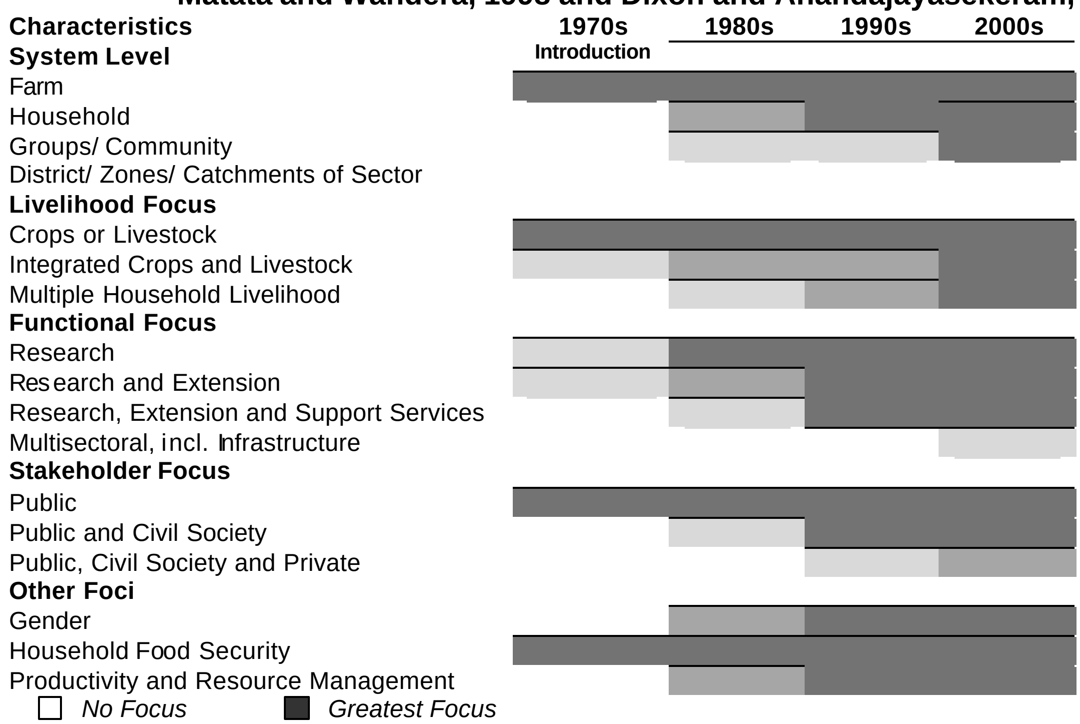
This chapter includes a brief description of the evolution of Farming Systems Research (FSR), followed by a discussion of the diagnostic phase of livestock systems research, supported by methods for participatory collection and analysis of livestock information in smallholder livestock production systems.

3.2 The Farming Systems Approach to Research

During the 1970s, "farming systems" evolved due to the perceived failure of conventional research approaches to address appropriate issues in less favourable environments, where the majority of resource-poor farmers live (Hall, 2001). In Eastern and Southern Africa, the concept was introduced during this period and spearheaded by the International Agricultural Research Centres (IARCs) (Matata and Wandera, 1998). By the late 1980s, the term "farming systems research" came into being, as it became evident that the two basic components (systems and research) constitute an approach. It is similar to the one used by Shaner et al. (1982), who termed it "farming systems research and development" (FSR&D), whereby the farm is taken as the basic starting point while actual development is part of the approach (Wolfert, 2002). In addition, the development of the notion that extension is an integral part of the research process, and extension personnel started to form part of inter-disciplinary teams, the approach has also become known as "farming systems research and extension (FSR&E) (Hildebrand, 1991). The knowledge derived from the research is disseminated to the farmers in the form of advice. This approach could perhaps be viewed as the classical application of research and extension followed recently (Wolfert, 2002).

The last three decades has seen a marked shift in the emphasis of farming systems research (Collinson, 2000). In Table 3.1 the main trends in the development of concepts and shifts in focus of farming systems research, especially in Eastern and Southern Africa, is illustrated:

Table 3.1 Evolution of Farming Systems Approaches from Inception in Eastern and Southern Africa (adapted from Collinson, 1982; Fowler, 1998; Matata and Wandera, 1998 and Dixon and Anandajayasekeram, 2000)



It was soon recognised that system interaction is critical for the successful adoption of any technology, and it is necessary to understand the whole system in order to effect changes. Within this framework, decisions made by farmers are mainly influenced by inter-relationships between technologies and the environment, economy, culture, attitudes, policies and rural societies. Farmers operate a complex system with multiple components, and it is not possible to effect change in one part without affecting the other parts of the system (Gryseels, 1988; Goncalves, 1995). Over time, methodologies have been developed as FSR has become better understood leading to a modification of the underlying principles. Initially, FSR focussed on technology generation only, but it is now widely recognised that the approach can also be used effectively to modify policy and for institutional support (Anandajayasekeram, 1997). Although several common features still remain, a number of aspects of these features have been identified (adapted from Shaner et al., 1982; Dillon and Hardaker, 1993; Anandajayasekeram, 1996):

- The farm is viewed holistically and includes the whole production system.
- The goal of FSR is to generate technologies to increase resource productivity for a target group of farmers. These technologies are based on biological and economic principles and it is intended for the target group to understand both how to implement the technology to increase productivity and why it works.
- Socio-economic and biophysical circumstances of the farmers are explicitly considered in developing the technology (refer to the previous bullet). Farmers' diverse objectives are respected when recommendations are derived.
- It is farmer-based and close researcher-farmer-extension linkages are essential.
- It is complimentary to on-station research and there is explicit recognition of the need to link FSR to research conducted in experiment stations and to extension activities.
- It is interdisciplinary.
- It is site- and target group-specific.
- The process should be continuous and dynamic.
- The choice of priorities reflects initial diagnostic studies of the whole farm.
- Research, and subsequent evaluation of a sub-system, recognises and takes into account the inter-relationships with other sub-systems.

3.4 The Systems Perspective

3.3.1 The Farmer's Place in Farming Systems

Farms vary in their resource endowments and in the family circumstances of the owners. The household, its resources, and the resource flows and interactions at the farm level are referred to as a farm system. The biophysical, socio-economic and human elements of a farm are interdependent, and can be analysed as a system from various points of view (Hall, 2001). This system includes a wide range of activities, often including a significant level of off-farm activities, to sustain livelihoods.

3.3.2 The Systems Research Perspective

Farming systems have been defined as "the way farmers satisfy their needs and priorities with the resources at their disposal, within the natural and socio-economic circumstances they find themselves in" (Collinson, 1982). Norman (1984) indicated that "a particular farming system arises from the decisions taken by the farming family with respect to the allocation of different quantities and qualities of resources to crop, livestock and off-farm activities in a manner that, given the state of knowledge that the household possesses, maximises the attainment of the household goals". Anandajayasekeram et al. (1991) defined the Kenyan view of farming systems as a multi-(inter- and intra-) disciplinary approach which seeks to generate and diffuse relevant technologies and/or recommendations for a specific group of farmers for their participation. The goal of this approach is to improve the productivity and sustainability of the existing production system(s) under different agro-ecological and socio-economic conditions. Therefore, it should include on-farm activities i.e. biophysical and socio-economic research, to ensure that all participants are jointly involved in the process of technology development and dissemination. The household has increasingly become the focus for on-farm research on farming systems (Scoones and Wilson, 1988, as cited in Cousins, 1988, Steyn, 1988).

In summary, a farming system comprises a collection of different enterprises that households are involved in, i.e. primary enterprises such as crops and livestock, and secondary enterprises such as processing, marketing and investments. These different enterprises interact depending on availability of different resources and inputs, within a framework of entitlement to resources, knowledge application and current prevailing circumstances. These various components, linkages and interactions are illustrated in Figure 3.1:

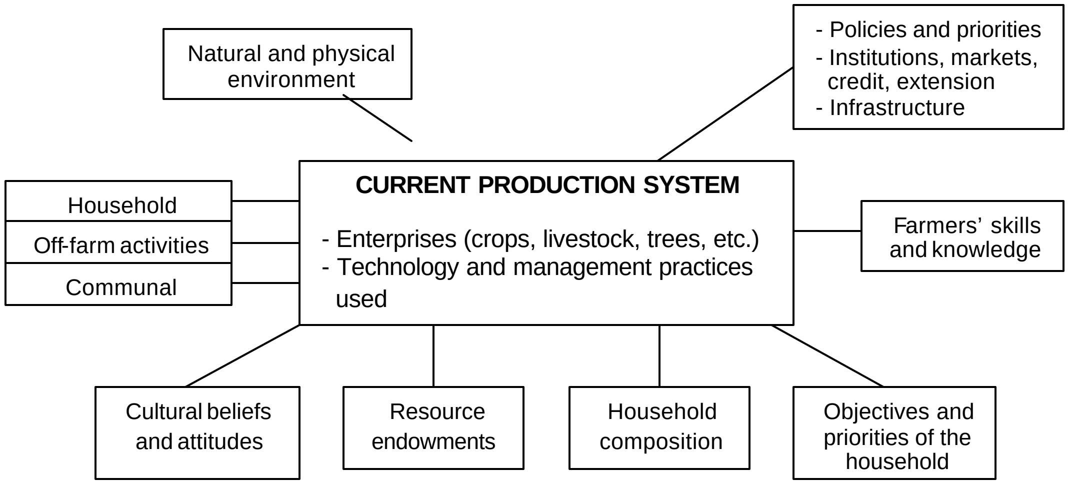


Figure 3.1 Factors Determining the Existing Farming System of Resource-Poor Farmers (adapted from Anandajayasekeram, 1997)

3.4 Farming Systems Procedures

The process of FSR involves several broad steps or stages, as illustrated in Figure 3.2. The level of detail and specific methods applied depend on the farming system being investigated (Gryseels, 1988; Anandajayasekeram, 1997). The various stages have been described frequently, most notably by Upton (1996) and Anandajayasekeram (1997). The following section provides a brief description of the FSR diagnostic phase, focusing on key issues of livestock systems research.

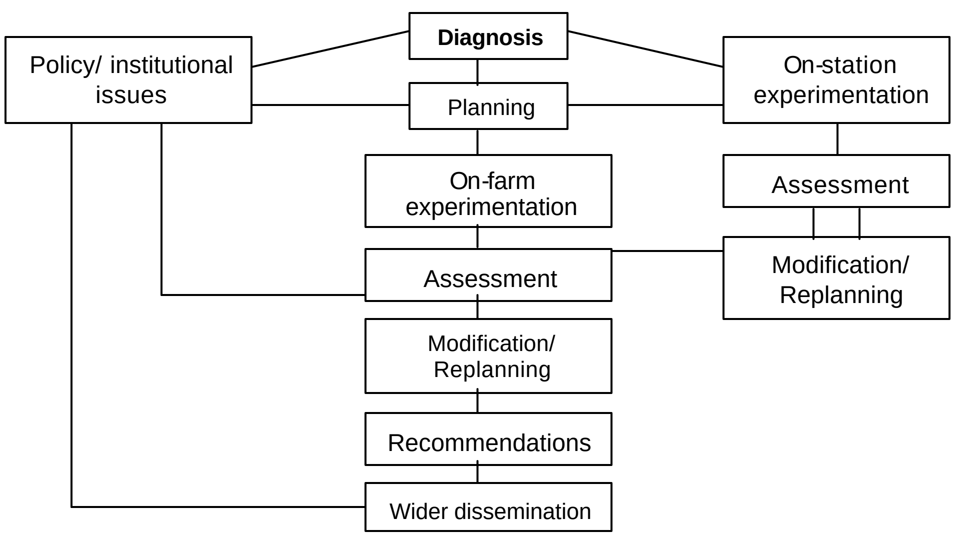


Figure 3.2 Stages in Farming Systems Research (Anandajayasekeram, 1997)

3.4.1 The Diagnostic Phase of Livestock Systems Research

The challenges experienced in conducting diagnostic livestock studies are often attributed to the specific characteristics of livestock keeping. These characteristics include (adapted from Roeleveld and van den Broek, 1996):

- The *physical environment* [farming systems (incl. utilisation of resources) and exogenous factors such as rainfall, temperature and soil interaction]
- *Productivity/ production parameters* (animal productivity, herd and manure management, products)
- The *human environment* (crop-livestock interaction, the socio-economic role of livestock).

The integration of these key elements is illustrated in Figure 3.3 :

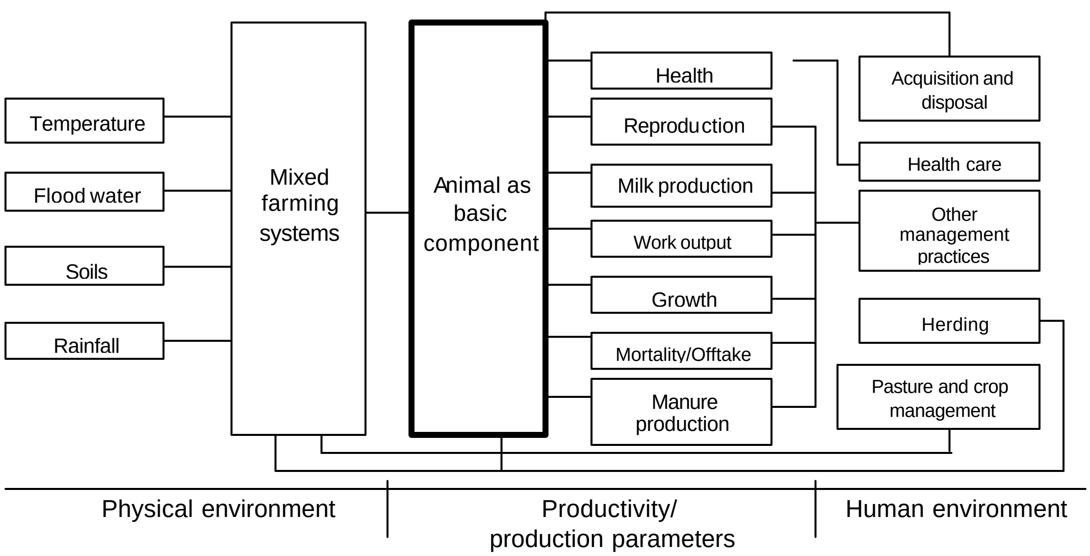


Figure 3.3 Relationships between Environmental Factors and Production Parameters of Cattle in a Mixed Farming System (adapted from Roeleveld and van den Broek, 1996)

The main components of a livestock system, as developed by Lhoste (1986) and discussed by Roeleveld and van den Broek (1996) are presented in Table 3.2:

Table 3.2 Main Components, Elements and Parameters of a Livestock System (Lhoste, 1986 as discussed in Roeleveld and van den Broek, 1996)

Components	Elements		Parameters	
Village territory and cropping system	Structure		• Forage composition • Distribution – surface	
	Primary production		• Phytomass • Chemical composition • Nutritive value	
	Utilisation by livestock		• Accessibility • Palatability • Intake	
	Evolution in time		• Seasonality • Interannual variation • Reproduction of ecosystem	
Interface	**Grazing behaviour**	**Balance system (Organic Fertilizer, Fertility) (link with cropping system)**		**Forage**
Herd	Structure (statistics)		• Species, breed • Number • Composition	
	Dynamics		• Reproduction (fertility) • Mortality • Off-take and growth	
	Animal		• Health status • Physiological status • Age • Individual performance	
	Management		• Management of the herd • Feeding • Reproduction	
	Products		• Meat, milk, wool, etc. • Manure, traction, etc.	
Interface	**Practice**	**Care Management Knowledge**	**Role of livestock (economic, cultural, religious)**	**Valorisation of livestock**
Livestock keeper	Tribe, family, history Projects (i.e. external interventions)			
	Organisation of livestock sector: various actors, role, decision structure			
	Relations with society Livestock and other services			
Interface	**Land tenure**	**Land use and management**	**Strategies: Transhumance, manure use**	
Territory	-	-	-	

The importance of analysing the interface between the different components should be emphasised within the context of farming systems research.

3.4.2 Participatory Collection and Analysis of Livestock Information

A summary of the methods for participatory collection and analysis of information on livestock is presented in Table 3.3 :

Table 3.3 Methods for Participatory Collection and Analysis of Information (Kirsopp-Reed, 1994 as discussed in Roeleveld and van den Broek, 1996)

Method	Topic for Information Collection and Analysis
Kraal visit	Livestock productivity Herd composition and size Species composition of livestock herds Aspects of livestock management
Ethnoveterinary question list	Farmers' disease nomenclature: symptoms, causes, traditional and modern treatments for various diseases
Mapping	
Social and wealth maps	Social organisation in the village: location of households with certain characteristics (i.e. owning livestock)
Opportunity and service maps	Location of services in the area (i.e. veterinary centre) and opportunities (i.e. a cattle market)
Resources and infrastructure maps	Location of natural resources used by the village livestock such as grazing areas in dry and wet seasons, reserved areas, cropland, watering points
Mobility maps	Frequency and purpose of travel by household members for livestock-related activities (herding, visiting markets, carting manure, etc.)
Body maps	Understanding people's knowledge and perceptions about the anatomy of an animal and the internal effects of diseases and treatments
Transect walks	Systematic walks in the area with farmers, giving an overview of the farming system, natural resources and other aspects relevant to livestock keeping
Diagrams	
Flow charts	A means of illustrating a flow of events in the farming system (i.e. nutrient flows)
Venn diagrams	Depicts social organisation: types of relationships and their relative importance (i.e. with whom farmers exchange information about livestock problems)
System analysis diagrams	A means of illustrating linkages among system components
Calendars and related tools	
Seasonality analysis calendar	Seasonality distribution of events (i.e. forage availability, births, mortality, disease occurrence, labour requirements, income and expenditures)
Activity calendar	Profile of the daily activities of the household members
Timelines and time trends	Presentation of historical events in an area (destocking programmes, dip construction, droughts and hunger periods, introduction of the plough)
Historical maps and transects	Exploring changes over time (i.e. size of grazing area, settlement patterns)
Preferences and proportions	
Wealth ranking	Analysis of the socio-economic differences among households
Preference ranking and scoring	A way of making farmers' criteria and priorities visible. Applicable to many aspects (i.e. disease problems, grass species eaten by cattle, problems of livestock keeping)
Matrix ranking	Similar to preference ranking and scoring, but covers more variables (i.e. kind of livestock with respect to its importance for income generation, food production, crop cultivation)
Proportional piling	Shows the relative importance of livestock-related issues (i.e. income from different sources or milk production in different seasons)

3.5 Analysis

It is clear that there are a multitude of variables that need to be considered and study designs that might be applied in the diagnostic phase of FSR. Many studies have been conducted to determine the effectiveness of these procedures and valuable lessons have been learned in applying these methodologies. Although these methodologies and procedures serve as a valuable guideline, especially in the diagnostic phase of FSR livestock research, they have to be adapted to the unique situation of each farming system and to each group of farmers. Studies in parts of Zambia, Mali and Tanzania have proved this (Bosma et al., 1996; Dicko, 1996; Wella et al., 1996).

This study included a variety of methods for data collection and analysis. In the South African case studies, there were kraal/homestead visits, transect walks and a questionnaire. The questionnaire, complimented by focus group discussions and key informant interviews, elicited a wide range of information, alluded to in Table 3.3. These included some ethnoveterinary information, social and wealth parameters, data on opportunities of the homestead (refer to row four), and resources and basic infrastructure. Although some aspects of participatory rural appraisal (PRA) such as calendars and related tools were not used, some information on seasonality was obtained through the questionnaires.

3.6 Conclusion

In most developing countries, FSR has significantly changed the way that agricultural research is conducted. Acknowledging the diversity of farmers' contexts and environments is central to the FSR process. Understanding the different components of the farming system, according to criteria used by farmers, will assist extensionists and policy makers to understand why farmers make particular decisions (Scoones and Wilson, 1988, as cited in Cousins, 1988).

As mentioned in section 3.2, consideration of policy development and institutional change in FSR are important in a dynamic environment to ensure that the research positively affects both farmers and policy makers (Upton, 1996; Mellor, 2000; Hall, 2001). Different farming systems produce a range of complex family objectives, all competing for the limited amount of available labour, land and cash on farms (Cox et al., 1995). No single product or aspect of the system can therefore be ideally managed (Collinson, 1998). This complexity necessitates new approaches to data collection, analysis and interpretation in order to objectively assess the impact of new technology, policy development and institutional change on smallholder and resource-poor farmers. It has become crucial to consider the importance of *ex ante* and *ex post* analysis to assess the interventions and approaches needed. Therefore, farming systems surveys require both quantitative and qualitative methods of data collection and analysis to be incorporated into current systems of research. However, possible integration of research methods, based on either simultaneous or sequential mixing of quantitative and qualitative values and techniques, is perhaps the best avenue to find the answers to questions posed, and being influenced by, FSR (Barrett, 2004). A discussion of qualitative and quantitative research, within the context of validity and reliability, has been summarised in chapter two, section 2.1.

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CHAPTER 4*

REVIEW OF SMALLHOLDER RUMINANT LIVESTOCK PRODUCTION SYSTEMS: THE SOCIO-ECONOMIC ROLE OF LIVESTOCK

Abstract

No single component of smallholder farms in developing countries has as much potential as ruminant animals to address simultaneously the inter-related factors of under-nutrition, poverty and environmental decline that prevent people from improving their livelihoods. In mixed farming systems, as a result of the interplay among farm families, animals, crops and social systems, the roles and contributions of animals to smallholder agriculture are complex. The projected increased demand for livestock products will result in far-reaching changes in the structure of smallholder livestock production.

Keywords: livestock, smallholder, multi-functionality, resources

4.1 Introduction

The challenge to overcome under-nutrition in the developing world remains one of the most elusive problems facing humanity. The threat is most serious in Africa, where an estimated 33% (138 million) of the population, mainly women and children, suffer from continued under-nutrition (FAO, 2000). In addition, per capita food production in Africa has declined over the past 25 years by 23% (FAO, 1995). The low productivity of the livestock sector in Africa is a primary reason why only small amounts of food of animal origin are available for human consumption. Sub-Saharan Africa comprises 14% of the world's livestock resources, but produces only 2,8% of

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the world's meat and milk (Otte and Chilonda, 2003). Hunger and poverty are closely related. Approximately 291 million people in Sub-Saharan Africa are classified as poor (IFAD, 2001). Lack of sufficient income to purchase food is a major factor responsible for household food insecurity; hunger itself contributes towards poverty by lowering labour productivity. Under-nutrition reduces resistance to disease, lowering achievements. There are more than 1.2 billion people worldwide living in poverty and many studies have indicated that poverty is worse in rural than in urban areas (Rosegrant et al., 2001; World Bank, 2001). In developing countries, more than 70% of total poverty is in rural areas (IFAD, 2001). In addition, under-nutrition is also found predominantly in rural areas, despite the fact that they are major areas of food production (Hall, 2001).

It is commonly argued that agricultural growth is one of the most effective mechanisms for economic development. However, the form that this growth takes determines how effectively poverty will be reduced (Mellor, 2000). Incomplete markets, poor market access, low productivity, poor human and animal health and a low-potential natural resource base all contribute to poverty. Smallholder farmers and the landless are disproportionately affected, weakening their ability to cope with fluctuations in the socio-economic environment and resource endowments (Devendra and Chantalakhana, 2002). Raising the productivity of labour-intensive smallholder agriculture and generating local demand for products and services should contribute to rural poverty reduction.

Smallholder farmers produce much of the developing world's food, but mainly through providing a livelihood and living directly from the land, as in most instances, alternative employment is not available currently. However, they are generally much poorer than the rest of the population in these countries and are less food secure than the urban poor. Although the majority of the world's population will live in urban areas by 2030, farming populations will not be much smaller than they are today (Hall, 2001). Reducing poverty and hunger in much of the world requires confronting the problems of small farmers and their families. It is crucial to investigate the underlying factors and issues that contribute to their poverty. It is also important to take cognisance of the many strategies and coping mechanisms used by resource-poor farmers to survive (Swanepoel et al., 2000b, Stroebel et al., 2004).

This review focuses on the role of livestock on the livelihoods of smallholder farmers, including income generation, food security, use of manure in nutrient cycling, draft animal power and social functions. It is followed by an analysis of the role of gender in livestock production, including constraints faced by women. The chapter concludes with a discussion of the socio-economic constraints to livestock production.

4.2 Livestock in Smallholder Farming Systems

With more than 18 billion livestock in the world (FAO, 2000), the direct and indirect effects of animals on productivity, sustainability, maintenance and resilience of the natural resource-base is indisputable. As markets expand, upstream and downstream linkages develop, creating a ripple effect throughout the economy. Both crop and animal production increase to feed an ever-growing population. As the demand for food increases, especially for animal products, strategies are needed to improve productivity to meet these needs. Table 4.1 presents estimates of the most important ruminant livestock species in the developed and developing world:

Table 4.1 Estimated Numbers and Percentage of Total for the Major Ruminant Livestock Species in the Developed and Developing World (adapted from FAO, 2000)

	Developed	% of the total	Developing	% of the total	Total
Cattle	331,438,301	25	1,006,726,420	75	1,338,200,721
Goats	29,194,570	4	680,739,129	96	709,933,699
Sheep	390,814,229	37	677,854,573	63	1,608,668,802

Nearly two billion people, 30% of the world's population, derive at least some of their livelihood from farm animals; nearly one person in every eight depends almost entirely on livestock. Domestic animals meet more than 30% of people's food and agricultural needs (ILRI, 1998).

Livestock use more than three billion hectares of grazing land (Seré et al., 1996). Livestock also provide the power to cultivate at least 25% of the total area under cultivation globally (FAO, 1995). The monetary value of fertiliser application from manure is more than US$800 million (Jansen and de Wit, 1996). The livestock population of Sub-Saharan Africa is illustrated in Table 4.2:

Table 4.2 Livestock Populations and Selected Output in Sub-Saharan Africa, 2000 (adapted from Hall, 2001)

Species	Million Head (2000)
Cattle	219.0
Sheep	189.0
Goats	194.0
Pigs	19.0
Poultry	809.0
Output	**Million Tons (2000)**
Total meat	8.0
Total milk	19.0
Total eggs	1.0
Cattle hides	0.5

In Sub-Saharan Africa, agriculture contributes 32% to the gross domestic product (GDP) and livestock production contributes 25% to the agricultural GDP of the region (World Bank, 2000; Otte and Chilonda, 2003). For instance, the livestock contribution to the GDP of the Central African Republic, Mali and Mauritania is 24%, 21% and 19% respectively (Blench et al., 2003). It is important to note that in Mali, more than 80% of the people are dependant and/ or involved in agriculture. This is the case in many other Sub-Saharan African countries (Blench et al., 2003). The monetary value of the livestock sector in Sub-Saharan Africa is estimated at US$41 billion (African Development Bank, 2000).

It is clear that no single component of smallholder farms in mixed farming systems in developing countries has as much potential as ruminant animals to address simultaneously the inter-related factors of under-nutrition, poverty and environmental decline that prevent people from improving their livelihoods. The roles and contributions of animals in mixed rural farms are complex, since there are close and varied relationships among farm families, animals, crops, social and agricultural systems (Devendra and Chantalakhana, 2002). Cattle and small ruminants (sheep and goats) will continue to be Sub-Saharan Africa's predominant livestock, especially in terms of poverty reduction, as they constitute approximately 72% and 16% respectively to the region's total livestock resources (when expressed in tropical livestock units (TLU) (Otte and Chilonda, 2003). They are regarded as assets, as they provide an array of market products and z-goods[7] (Tapson, 1991; Nkosi, 1994). Draft animal power is used to plough land, contributing substantially to nutrient recycling through fertiliser application (with adequate management practices). This also serves as an important economic mechanism for increased crop yields. Smallholders raise 90% of the livestock found in developing countries (Nicholson et al., 2001a). For example, in Southern Africa, more than 70% of all ruminant livestock are kept under smallholder farming conditions (Swanepoel et al., 2002). In Kenya, smallholder farmers own more than 80% of the total dairy cattle population and produce 70% of the domestically marketed milk (Omore et al., 1999). The contribution of poultry to household food security of smallholder farmers should never be underestimated. In the Limpopo Province of South Africa, 74% of farmers keep chickens compared to 41% who keep other livestock (cattle, goats, sheep and pigs) (Schuh, 1999).

Animals feed people and soils, generate income and are often the most valuable capital assets of small farmers (ILRI, 2003). Improved animal production is often presented as one of the best avenues for a subsistence producer to become a small commercial entrepreneur (Kadzere, 1996).

4.3 The Livestock Revolution

The human population is projected to reach eight billion by the year 2050 with increasing migration to urban areas (Brown and Kane, 1994; Preston, 1998; Delgado et al., 1999). By 2020, 800 million people will not have enough to eat (CAST, 1999; Delgado et al., 1999; Nicholson et al., 2001b).

[7] Basic commodities that are not marketed but are consumed by the household for subsistence.

By 2020, the demand in developing countries will increase by 87% for meat and 75% for milk. In global terms, this will mean that in 2020 people in developing countries who comprise 75% of the world population will consume 60% of global milk and meat production[8]. This represents a major increase in the demand from the early 1990s, when developing countries consumed only 47% of milk and 40% of meat of world supply (Delgado et al., 1999; Nicholson et al., 2001b). The demand for animal products increased by more than five percent from 1982 to 1994 in developing countries, as opposed to only one percent in developed countries (Nicholson et al. 2001b). Milk consumption in the developing world increased by three percent per year over this time frame. The amount of calories provided by animal products increased from nine percent to 11% during the same period. However, it has not been qualified whether it is the poor or the middle-class that benefits most from this increased consumption of milk and meat.

This increased demand for products, coined the Livestock Revolution (LR), is driven by population growth, economic growth with accompanying higher incomes and increased consumption. In contrast, demand in developed countries will only increase as the population increases. According to classic economic theory, producers will respond to this accelerated demand by increasing supplies.

According to Nicholson et al. (2001b), this increased demand for animal products can have two different consequences. On the one hand, increased pressure on natural resources is likely if sufficient feed is produced to meet the growing livestock demand (Vercoe et al., 2000). Alternatively, the increased demand presents an opportunity for poverty alleviation by stimulating economic growth by the participation of thousands of smallholder producers (Blake and Nicholson, 2003). The main issues regarding the LR can be characterised as follows:

<u>Nutrition</u>: Given that malnutrition affects many pregnant women and almost 30% of all children younger than five years, livestock products play a critical role in providing balanced diets and adequate levels of nutrients, especially for the poor (Neumann

[8] Projection made during the late 1990s.

and Harris, 1999). Livestock products are good sources of high quality protein, calcium and iron, all of which are likely to be in short supply to people in developing countries. Securing both adequate amounts of food and a balanced diet remains the primary issue for many of the poor in developing countries.

Food security: The main concern should be whether poor people have (a) the ability to purchase or produce food that will provide them with adequate diets or sufficient income to purchase needed foods, and (b) physical access to food. Food prices are predicted to decrease in the long term, despite the increase in the amount of cereal used as animal feed (Delgado et al., 1999). The effect of the LR on food security of the poor is predicted to be far less important than the effect on their income. Increasing the nutritional value of the human diet while utilising feeds that can not be used by people are the most important predicted benefits of the LR (Fitzhugh, 1998). In addition, practices that increase animal productivity will result in increased income. Kenyan households with improved livestock invest more in animal feed, veterinary services and artificial insemination than those owning native cattle (Shapiro et al., 2000). These households purchase legume and vegetable seeds to produce protein and vitamin-rich crops for family consumption.

Income of the poor: Poor people have few opportunities to increase their incomes because they lack access to land and capital. Smallholder livestock production enables the poor to earn income from animals grazed on communal pastures or fed household waste. Livestock production (in many cases small stock) offers one of the few rapidly growing markets that poor rural people can participate in even if they lack substantial amounts of land, training and capital (Delgado et al., 1999). The importance of livestock for women's income in developing countries has been widely emphasised (Quisumbing et al., 1995; Vladivia et al., 1996) (this issue will be discussed in detail in section 4.5). It has been argued that the poor earn more income from livestock than the wealthy (Delgado et al., 1999).

Therefore, the rapid increase in demand for animal products, especially for milk and meat, is predicted to make livestock production the largest share of the growth of global agricultural output by 2020 for developing countries (Delgado et al., 1999; Nicholson et al., 2001b; Blake and Nicholson, 2003). However, the projected increase in demand can not be met only by increasing animal numbers: increased productivity is needed also. With increased efficiency, effective management including better health and nutrition and sustainable production methods, the supply needed to meet the increased demand for livestock products can be met. To enable smallholder farmers to participate effectively in the LR, changes at the technological and policy levels are required (Vercoe et al., 2000).

Increased production of meat in Sub-Saharan Africa will come primarily from cattle, sheep and goats reared on rangelands, especially in arid and semi-arid areas, or in mixed farming systems in higher potential areas (Vercoe et al., 2000). However, Delgado et al. (1999) indicated that poultry had the fastest total production growth rate in developed and developing countries between 1982 and 1994, with the fastest growth in developing countries of 7.8% compared to 3.8% in developed countries.

Increasing food security, income generation and energy provision are the major projected effects of the LR. However, rapidly increasing livestock production may cause serious damage to the environment. In contrast, when production levels off and sustainable practices are followed, the contribution of livestock to the environment can be highly beneficial (de Haan et al., 1997; Steinfeld et al., 1997). A detailed analysis of the effects of livestock production on the environment will follow in chapter five.

4.4 The Multifaceted Role of Livestock in Sub-Saharan Africa

Income: Ethiopian farmers in mixed livestock-crop systems earn half or more of their cash income from animal products (ILCA, 1987). Income is generated through sales of animals, milk, meat, hides and manure, and is a critical source of household income. This is substantiated by Gryseels (1988) who reported that livestock provide most of the cash income and gross margin in smallholder crop-livestock farms in the Ethiopian highlands. Farmers in Burundi increased production from 51% to 84% by introducing better adapted cows, effectively increasing their income by 165% (Jacob, 1995 as cited in Peters, 1999). Smallholders who combined livestock and crops in Zimbabwe earned twice as much as those farmers who produced only subsistence crops (Gittinger et al., 1990). In high potential areas, dairy production from cattle and goats tends to make the largest contribution to total farm income, followed by other species and products (Falvey and Chantalakhana, 1999). In addition, incomes are enhanced by improved access to markets through transport provided by animals. Livestock, especially large ruminants, are also the principal saving mechanism for smallholder farmers to buffer against crop failures and serve as a reserve that is readily convertible to cash (McDowell, 1980; Chilonda et al., 2000; Swanepoel et al., 2000a; 2000b; Nicolson et al., 2001a).

Nutrient Cycling: More than 65% of livestock are found in the developing world, managed by smallholder farmers in mixed farming systems (Nicholson et al., 2001a; ILRI, 2003). An important benefit of ruminants is that they thrive on feeds inedible by humans. “Waste” products such as crop residues, by-products and grasses and trees on marginal lands can be converted to high value products when fed to animals (Devendra and Chantalakhana, 2002).

Manure: The mechanism of folding has been widely used to use manure as potential fertiliser. Ruminants are left overnight in the field after harvest. Not only are they making use of the crop residues and weedy plants, but also spread manure over the field, thereby maintaining soil fertility (Devendra and Chantalakhana, 2002). Manure is one of the major sources of income-in-kind. In Kenya, one kilogram of dry manure has been estimated to have a value of 28% of the price of one liter of milk (Lekasi et al., 1998)[9].

Draft Power: More than 25% of the global annual crop yield is tilled using animal traction. This trend is evident in South Africa where 23% of the homestead gardens in

[9] However, in the course of a day, cows often are producing three litres of milk and considerably more manure so the value of the manure may exceed that of the milk. If it is assumed that the typical Kenyan cow weighs 450 kg, eats 2.5% of body weight (BW) and that the diet digestibility is 55%, the cow will produce 6.2 kg of manure; the value of the manure is 57% of the value of the milk.

the eastern part of the country are prepared with cattle and only 18% of the plots are tilled with tractors. Steyn (1982) reported that 100% of the rural households in some villages in the south eastern part of the country plowed with animals. In 1994, the South African Network of Animal Traction (SANAT) reported that more than 500 000 oxen and various other animals are used by 40% to 80% of the agricultural rural households in some areas in South Africa (Starkey, 1995). Gryseels (1988) found that in Ethiopia, there was a 60% increase in average cereal production over a six year period for farms using two oxen for ploughing, compared to those tilling without oxen. Although most smallholder farmers use animals for ploughing and transport (Fowler, 1995), they are also used for harrowing, seeding, weeding, mowing, raking, fertiliser spreading and threshing.

Social Role: The social contribution of livestock is important because animals confer status in many cultures (McCorkle, 1994). The fact that socio-economic status is a very useful predictor of successful and progressive cattle farming underscores the multifaceted role of livestock (Bembridge and Burger, 1977). Although there are numerous definitions of social status, in Zimbabwe education, income, size of enterprise (number of cattle owned), social participation in district affairs and standard of living were important variables in determining socio-economic status (Bembridge and Burger, 1977), an observation substantiated by Düvel and Afful (1996). The value of cattle for traditional ceremonies includes lobola (bride price), funerals and ceremonial functions (Mokoena, 1998).

Small Ruminants: It is justified to have a separate, focussed discussion on the role of small ruminants, especially goats, as 94% of the 674 million goats of the world are found in the developing countries (FAO, 1996). Small ruminants play a major role in smallholder livelihood strategies. Africa and Asia account for almost 81% of this number, with the largest concentrations in Africa found in Nigeria, Sudan, Ethiopia and Somalia. A variety of breeds exist that produce fiber, skin, meat and milk (Devendra, 1999). They are particularly important in drier and harsh environments, notably the arid and semi-arid zones. Some researchers argue that unique attributes include water metabolism, more tolerance to tannins and increased disease resistance (Devendra, 2001). However, many of these unique attributes are not substantiated and require further research.

Although farmers keep cattle for meat and draft power, poor farmers own sheep and goats as insurance against drought. Extensive socio-economic studies in India showed that 44% of the landless farmers (earning less than US$24 per capita per annum) owned the highest proportion of goats, dropping to 39% of the farmers who had only 0-0.5 ha of land (Devendra, 1999). The ownership of small ruminants increases as land becomes scarcer, and confirms the view that the poorest farmers (those who can not afford cattle) obtain food and financial security from owning these animals. They can be regarded as "inflation-proof assets" (Vercoe et al., 2000).

Human Health: The effects of animal products on human nutrition in developing countries depend on demographics, income levels and the commodities consumed (CAST, 1999). Children consuming appropriately-sized portions of animal products will consume the required amounts of calories and other nutrients. This is especially important for infants, children and women in developing countries to avoid deficiencies of amino acids and micronutrients (Neumann and Harris, 1999). Recognition of the benefits of animal products in the diet is essential as it has major importance for optimising human performance in chronically mild to moderately malnourished populations (Allen, 1993). The effects of livestock development on the well-being of different family members are cited in the literature (Lele, 1986; Quisumbing, 1998), and are of great concern to policy makers and researchers. Several studies have been conducted to correlate the rate of consumption of animal products to disease patterns (Calloway, 1995; Latham, 1997; Hu and Willett, 1998). The conclusion is that there is a lower incidence of heart disease and cancer if animal products are consumed in moderate quantities.

Food Security: For smallholder farmers, the production of food such as maize, vegetables and fruit for home consumption is a basic activity for family subsistence. At the same time, different species of livestock are also raised for household consumption, including milk, meat and eggs. Generally, poultry, pigs and small ruminants are slaughtered for home consumption, while large ruminants serve as family long-term savings, referred to as “banks on hooves” (Devendra and Chantalakhana, 2002). Small ruminants are often used to pay smaller expenses, i.e. school fees and health costs (Swanepoel et al., 2000b). When crop production fails due to floods, droughts or diseases, ruminants, especially large ruminants, provide food security to smallholder families (Fitzhugh, 1998).

4.5 The Role of Gender in Livestock Development

Gender division in agriculture plays an important role in livestock systems and men, women and children participate to varying degrees in animal husbandry. However, the role of women in the household production system usually goes unnoticed, because women’s activities are usually not recorded in employment records (Tangka et al., 2000). In Sub-Saharan Africa, 47% of the agricultural population of 384 million people is women (Hall, 2001). Women fulfill many diverse functions in the livestock system, in addition to their household and childrearing roles (Jabbar et al., 2000). A summary of the main activities in some countries in Sub-Saharan Africa is provided in Table 4.3:

Table 4.3 Summary of the Main Activities of Women in Livestock Development in Sub-Sahara Africa

Country	Main Activities of Women in Livestock Development	Reference
Algiers and Somalia	Women play a more active role and even herd livestock most of the time.	Bourgeot (1987) Martins (1990)
Benin and Niger	Duties not rigidly assigned in some pastoral systems because the harsh environmental conditions dictate who takes charge regardless of gender. For instance, women are responsible for milking in some parts.	Martins (1990)
Burundi	Women have greater agricultural responsibilities than men, although they are still viewed as the assistants to the men.	Martins (1990)
Ethiopia	Men are responsible for all strategic decisions on herd composition, off take management, slaughter and sales.	Coppock (1994) Data (1998)
Kenya	Women’s responsibilities include dairy production, caring for animals and identification of illnesses. Responsible for up to 81% of the milking activities.	Grandin et al. (2001)
Mali	Goats and sheep are mainly owned by women for cash income for various purposes.	Martins (1990) Devendra and Chantalakhana (2002)

Nigeria	Regarded as having usufruct privileges. However, this is mainly related to cattle.	Waters-Bayer (1988)
South Africa	Women own mainly small stock and all the poultry. Cattle are owned in exceptional cases i.e. through marriage, but the number is limited. There is some consultation in the marketing process of cattle.	Swanepoel et al. (2000a,b) Swanepoel et al. (2002)

In the pastoral systems of Kenya, women are mainly responsible for dairy production, caring of animals and identification of illnesses (Grandin et al., 2001). Up to 81% of the milking activities are the responsibility of women. Men are responsible for all other activities, mainly regarding strategic decisions of herd composition, offtake management and slaughter and sales. Similar examples are found in Ethiopia, Niger and Sudan (Coppock, 1994; Data, 1998). However, in some examples in Somalia and Algeria, women play a more active role and even herd livestock most of the time (Bourgeot, 1987; Martins, 1990). Responsibilities for livestock management are not rigidly assigned in some pastoral systems because the harsh environmental conditions dictate who takes charge regardless of gender. For instance, women are responsible for milking in some parts of Benin (Martins, 1990). Processing of cheese from the milk provides needed cash to the household. Livestock are generally owned by men, with women and children regarded as having usufruct privileges. However, this is mainly related to cattle, and women usually own small ruminants obtained as gifts from family or from the husband, especially goats (Waters-Bayer, 1988). In Mali, a survey among ethnic groups indicated that goats and sheep were mainly owned by women, either through inheritance or through purchase with income from selling agricultural products (Devendra and Chantalakhana, 2002). These small ruminants are used as cash income for various purposes, mainly for paying school fees and health care (Martins, 1990). Similarly in South Africa, women do own cattle, although in small numbers (Swanepoel et al., 2000b).

In agropastoral systems, the main characteristics of women's role in livestock development are similar to those for pastoral systems. Ownership, rights of disposal and use of livestock-derived income varies by gender and among ethnic groups (Martins, 1990). However, in general, women sell milk and dairy products and use the proceeds to pay for small, regular purchases related to children and the household.

One of the main differences between gender roles in pastoral and agropastoral systems is that in the latter, control and access to resources and benefits are based on the responsibilities assigned according to needs and household tasks, rather on the basis of gender roles or patriarchal ownership (Bruggeman, 1994).

In mixed crop-livestock systems, women are involved to a greater degree than in pastoral and agropastoral systems, although there is regional and ethnic variation. Tasks include harvesting, feed-related activities like transport, and sale of milk products through formal and informal channels (Tangka et al., 2000). Women in Burundi, for instance, assume far greater agricultural responsibilities than men, although they are still viewed as the assistants to men (Martins, 1990). Men make decisions about goat keeping, after consultation with their wives. In the Ethiopian highlands, women are involved in cattle farming more than in arable farming, while men take care of the oxen. In marketing of livestock, men and women take joint decisions (Whalen, 1984). In the Limpopo Province of South Africa, Mokoena (1996) found that the use of animal traction depends on the gender of the head of the household. Those households headed by men make significantly more use of animal traction than those households headed by females (Moholwa, 1995).

4.5.1 Constraints Faced by Women in Improving Livestock Production Systems

Various factors related to gender roles contribute towards the low productivity of smallholder livestock production systems. Low adoption of available livestock technologies due to lack of institutional credit and limited capital is a major constraint (Jabbar and Ehui, 1998). Female farmers are particularly constrained in raising livestock due to lack of capital. In many cases, social standing and wealth are used as alternative collateral security in credit schemes for smallholders (Freeman et al., 1998). These conditions discriminate against smallholders, especially women, who usually cannot meet these requirements. This forces them to resort to informal credit schemes with exorbitant interest rates, a serious deterrent to entry into livestock farming. Tangka et al. (2000) reported that in the intensified dairy production areas of

Kenya, women's inability to obtain credit was a serious constraint to improving dairy productivity.

Traditionally, women's family responsibilities and primary care-giving roles limit the time spent on non-domestic activities, including livestock production. Women in Africa spend most of the day performing household and children care activities leaving little time to participate in extension activities and training to improve their knowledge and skills (Quisumbing, 1994). In many instances, extension activities are scheduled when it is not possible for women to attend due to domestic responsibilities. In addition, since most of the extension officers are men, women frequently are not included in the question and discussion sessions.

Access to agricultural extension training and services is an important factor enhancing agricultural productivity (Overholt et al., 1985). Women are rarely targeted for livestock-related training and extension services, and information is usually aimed at men. It often is assumed that men pass the information on to their wives, that women are less literate and will not understand the information, and that women are preoccupied with household duties (Paris, 1992). In addition, training that is provided to women is rarely on agricultural productivity, but instead focuses on home economics. In Kenya, Maarse (1995) has found that the first training in zero grazing was provided to an audience that was 69% male, although women are responsible for most of the dairy operations. The consequences of these assumptions are severe, especially in female-headed households.

To improve food security in Africa, animal husbandry must become more productive (Winrock, 1992) which requires the equal training of women and men in livestock development systems. Without helping women to farm, there can be no realistic turnaround in Africa's food production (Gladwin and McMillan, 1989).

4.6 Constraints to Livestock Production Systems

Agricultural planners often have difficulty in understanding the complexity of livestock production systems and how they function. They have rightly stated that this has been primarily a problem of quantification and comprehension. Smallholder livestock systems are complex, adapted to different regions, with various external marketing linkages.

At the macro level, some of the reasons for the poor performance of livestock production systems include:

- Inappropriate policies
- Institutions not responsive to the needs of smallholder producers
- Limited resources
- A failure to develop appropriate technologies for smallholder producers
- Limited access to markets, and
- Limited management experience and applied knowledge.

Constraints to productivity include factors related to the environment, social condition of the household, training and knowledge of the livestock owners and the inherent adaptability of the animals. Milner-Gulland et al. (1996) observed that farmers in semi-arid Sub-Saharan Africa often cope with extremes in climate and use output per unit labour rather than output per unit area as a criterion for management decisions. The emphasis on labour efficiency is important in an analysis of the underlying constraints faced by smallholder livestock production systems.

In many regions, especially the arid- and semi-arid areas, water shortages are the major constraint to efficient livestock production. Inadequate forage availability is a consequence of low rainfall (Swanepoel et al., 2000b). In the Limpopo basin of Southern Africa, estimates of mortality rates are as high as 60% per annum and these rates increase significantly during multi-year droughts (Swanepoel et al., 2000b). During droughts in Kenya, Ethiopia and Zimbabwe, stock losses were between 30% and 98%. There is a significant difference in mortality rate between cows with calves, and dry cows, oxen and bulls (Bekure et al., 1991; Coppock, 1994; Moyo, 1996). Calf mortality rates are highest, followed by cows that have recently calved.

The traditional response to drought by stock owners in the communal areas is to move their animals (Sweet, 1998). In Namibia, owing to the spatial variability of rainfall and the seasonal availability of surface water, seasonal movements are the norm, especially in the dry areas. In the communal areas especially, there are localised concentrations of permanent settlement where the crop fields are situated and other areas with relatively light grazing pressure. In these lightly grazed areas, many households own or share "cattle posts" located near hand-dug wells or, occasionally, boreholes. During droughts, these areas used to serve as the first line of defence when the feed around the settlements had been depleted. Access to these "drought boreholes" often is not restricted (as they are invariably far from the homestead) so that these areas have become part of the regular grazing system and no longer serve as safety nets. When droughts recur, new boreholes must be dug.

Conversely, in severe droughts or natural disasters, herders who have lost their herd or most of their stock, and do not have the resources to restock, often become sedentary around small towns or food aid distribution centres (Huysentruyt et al., 2004). In some cases, these herders quickly lose their stock as the areas around the "settlements" become overgrazed. Among the Maasai in Kenya, a minimum of 8 - 12 head of cattle are necessary for trekking herders to survive off the herd's flow of blood and milk. It would seem that this number of cattle arises because the indigenous breeds' lactation rates are relatively low and multiple herders are required to supervise and guard these pastoral herds (Huysentruyt et al., 2004).

Loss of cattle due to disease is very common. The diseases are attributed to poor veterinary extension, unavailability and high cost of drugs, compromised immune function due to poor nutrition, as well as poor management practices. Some of the common diseases such as tick borne diseases and contagious abortion are observed during the early wet season. Parasitic and viral diseases, which are mainly vector transmitted, also cause severe economic losses. Pesticide control of ticks and insect vectors is expensive and the pesticides are sometimes not available, making sustainable control difficult to achieve. Tick infestation is still a problem because of a shortage of dip tanks and chemicals. In some areas, wildlife constitutes a reservoir of diseases and a source of infection. Measures to control these diseases have been developed, but underfeeding, poor management and the use of non-adapted genotypes result in many of these diseases becoming severe. One of the main factors hindering the sustainable control of livestock diseases is the inability of many countries to maintain effective disease surveillance (Winrock, 1992; Price Waterhouse Coopers, 1999). Effective diagnostic capacity, including functional veterinary services, also is lacking. In addition, treatment of animals in communal areas usually is costly, as treated animals are immediately reinfected upon returning to the communal area (Dreyer et al., 1999). Incorrect dosing of prescribed drugs compounds the disease problems. Due to misinformation and lack of training, many farmers do not provide an adequate dose to their animals to save money or overdose them using the logic that if some is good, more is better. When the animal starts to recover, medication is discontinued before the prescribed course is completed. The result is heightened resistance to the drugs, especially antibiotics, some of which are also used in humans. Medical costs also escalate. In both these cases, farmers are likely to lose faith in the veterinary system, and, as a result of their mistrust and the incorrect dosages of drugs, animals remain ill (Machila et al., 2001).

Poor animal genotypes (usually non-adapted) fail to produce adequately, even in environments where feeds are available, diseases can be controlled and management is satisfactory. Examples of this can be found in some areas in Kenya (Ojango, 2000). In many countries in Sub-Saharan Africa, priority has not been given to identifying production traits among indigenous farm animals and establishing sustainable livestock improvement programmes. The indigenous animals usually are well adapted to areas in which they occur naturally with greater disease resistance, heat tolerance and ability to utilise low-quality feeds. Yet many countries still import exotic breeds. In Kenya, of more than 300 grandsires and sires used between 1986 and 1997 for both commercial and small-scale farming, only 29% were from local populations with the rest being imported from the United States of America and European countries (Ojango, 2000). These cross breeds usually produce well when fed an adequate diet. However, low quality feeds, typical of those frequently available in Kenya, leads to low productivity. The impact of improved germplasm on food production has not been high, although efforts by the International Livestock Research Institute (ILRI) are focusing on the challenge. Unplanned and intentional cross-breeding between indigenous animals and exotic ones has also occurred with the result that indigenous breeds or breed types are disappearing. However, efforts by ILRI may improve this situation.

4.7 Conclusion

The framework that emerges from this review is dearly one of urgency and at the same time of complexity. The urgency stems from the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production. The complexity stems from livestock's use by smallholder agriculture for multiple needs, thereby influencing the livelihood strategies of the smallholder family. The purpose of livestock is determined by human needs, and technology translates these into different levels of natural resource use and sustainability. Approaches to improving livestock productivity should be area and context specific, and this remains one of the major challenges.

Further, productivity measures in smallholder systems are generally low. The word “production” is relative, especially when comparing two systems which from the outset have different objectives, as is obviously the case between smallholder communal and commercial producers. The remark by Little (1980) remains highly appropriate: “*There are few development issues today which entail a greater complexity of sociological, economic and ecological variables than that of livestock in Sub-Saharan Africa*”.

4.8 References

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CHAPTER 5*

REVIEW OF SMALLHOLDER RUMINANT LIVESTOCK PRODUCTION SYSTEMS: THE ROLE OF LIVESTOCK IN NATURAL RESOURCE MANAGEMENT

Abstract

Livestock never interact with natural resources in isolation, but people as livestock managers play a deciding role and are affected by biophysical, economic, social and policy factors. In this context, an integrated approach to natural resource management is required. The impact of livestock on natural resources depends on and is influenced by many factors, including greenhouse gas emissions and nutrient cycling. In addition, social systems such as property rights and land tenure systems influence the management practices of the farmer. However, there are large areas where livestock have remained in equilibrium with natural resources and even more importantly, are contributing to maintain ecosystem health, biodiversity, flexibility and societal cohesion. Livestock and the environment can achieve a balance while at the same time fulfilling humanity's food needs and contributing to sustainable economic growth.

Keywords: livestock, environment, interaction

5.1 Introduction

One of the great challenges facing the world in the coming decades is to preserve natural resources while simultaneously producing sufficient food to satisfy the demands of a growing population. This is stated within the context of sustainable land management (SLM), which implies the combination of technologies, policies and

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activities aimed at integrating socio-economic principles with environmental concerns (Dumanski and Smyth, 1993). Therefore, the extent to which land degradation, water scarcity, and global warming are problems depends on human-environment interactions. The basis of these interactions, in the developing context, is the continuum between poverty and environmental degradation (Pell et al., 2003).

Land degradation: Approximately 37% of the world's total land in use (8.7 billion hectares) is degraded or seriously degraded. Of the total agricultural land in use (1.4 billion hectares), 39% is regarded as degraded. For Africa, 65% of the total land used for agricultural production (187 million hectares) is degraded (Scherr, 1999).

Water scarcity and pollution: More than 30 countries have less than adequate water supplies, and a large part of the global water supply is unsafe due to pathogens, partly due to livestock and industrial pollutants (World Bank, 1992).

Global warming: Some scientists have argued that average global surface temperatures are expected to rise between 1.4^0C and 5.5^0C over the next 100 years, while the frequency of climatic extremes is expected to rise dramatically (Hall, 2001).

One strategy to improve the situation is to integrate environmental concerns into efforts to achieve food security (Hutchinson et al., 1991; Barraclough, 1996; Pretty et al., 1996). It is critical to realise that food production largely depends on the condition of the resource base. In addition, sound management of natural resources is needed for production, secure access to food, and for hunger alleviation (Thrupp and Megateli, 1999).

Traditional systems of natural resource management are integral in sustaining food production in the face of numerous constraints imposed by the environment and limited knowledge of how to improve productivity (Devendra and Chantalakhana, 2002). For a farming system to be sustainable, farm incomes must be increased.

Livestock never interact with natural resources in isolation, but people as livestock managers play a pivotal role and are affected by biophysical, economic, social and policy factors (Tarawali et al., 2001). In this context, an integrated approach to natural resource management is required. The impact of livestock on natural resources depends on and is influenced by many factors, including management practices and the agroecology. If basic necessities are not secured, environmental protection and sustainable use of resources become unimportant. This has been demonstrated in very marginal areas in Sudan and Tanzania (Devendra, 2001).

This chapter focuses on the varied impacts of smallholder livestock production systems on the environment within the context of sustainable natural resource management. It reviews the complex social issue of land tenure and property rights and describes and analyses the role of livestock in grazing systems in arid and semi-arid, and mixed farming systems. The chapter concludes by highlighting specific interactions of livestock with wildlife, the forest environment, use of manure and contributions to the emission of greenhouse gasses.

5.2 Influences of Property Rights on Natural Resource Management

The property rights systems in Sub-Saharan Africa that govern access, use, and management rights are largely still communal with households having certain rights to cropland and shared access to rangeland, forest and water resources[13] (McCarthy et al., 2002). These systems evolved when populations were low and there was limited environmental degradation. However, as the population increased, traditional leadership was replaced with modern governmental structures and adaptation of these systems became essential. Especially in the arid and semi-arid areas where extensive and semi-extensive livestock production systems form the basis of the households' income, land reform policies have resulted in increased productivity. Niamir-Fuller (1999) found that broad claims to pastoral resources and attempts at privatisation have led to a breakdown of traditional community management and to situations of open-access. Attempts at state-controlled interventions failed as a result

[13] However, there are important exceptions where most of the smallholders own their land, i.e. Kenya.

of domination and unequal distribution (Swallow, 1994) in Kenya and Niger (Ngaido, 1995; Asfaw and Tolossa, 1997). Instances of failure to promote sedentarisation are offset by examples of spontaneous, pastoralist-driven sedentarisation in East Africa and elsewhere[14]. In many instances, the decision of pastoralists to become sedentary is driven by external factors (Grell and Kirk, 1999). In Namibia, one of the external factors was the large-scale, pre-emptive fencing of rangeland that was caused by increased population pressure which decreased the supplies of water and forage (Devereux, 1996).

However, government-supported privatisation of land ownership is not the only avenue for land development, especially where environmental risks affect land use and livestock productivity, as is the case in semi-arid areas (Naimir-Fuller, 1999). When rangelands are communal, it is possible to maintain the mobility and flexibility needed to provide a safety net for periods of drought (Scoones, 1995). Therefore, where communities can manage their rangeland resources, common property may be most appropriate (McCarthy et al., 2002). In contrast, in open access areas, the interest of the individual may often conflict with those of the community. In these "free for all" situations, land degradation is most severe. It is what Hardin (1968) postulated as the "tragedy of the commons" in Southern Africa: where individuals farm for personal gain and sustainable practices essential for maintaining soil and animal productivity are not adopted (Vink and Kassier, 1988; Boonzaier et al., 1990; Clarke, 1991).

This discussion was summarised by Knox McCulloch et al. (1998), using an example of a community combating soil erosion. Levels of collective action vary, as few individual farmers on common property are likely to adopt technology to combat erosion on their own. Spatial differences are evident between farmers' plots and the common area. Security of property rights varies temporally, depending on the land tenure arrangements in the common area, so that a very high level of collective

[14] Here the issue of sedentarisation is highly variable. Where the environment permits, it may be preferable to promote sedentarisation in terms of development of mixed farming systems. However, in arid and semi-arid areas, maintenance of mobility and flexibility is needed to provide a safety net for periods of drought.

action is required to sustain activities to protect the environment. Social forestry is an example of a practice that requires individual action with almost no coordination by the community. Similarly, watershed management often demands a long time horizon and an extended spatial scale, although specific components like contour ploughing can be applied on smaller areas, with more immediate pay-offs (Knox McCulloch et al., 1998).

These action-levels make it possible to determine whether property rights or collective action are likely to be constraining or enabling factors to make the most appropriate choice of technology, or combinations thereof.

The interaction between traditional land, so-called “state land” and communal resources is an important factor to consider in gauging the effect of different land use systems and technologies on the environment. Moreover, the security of access to land is a critical determinant of adoption of technologies for increased production (Viljoen et al., 2002). Stock owners in the Limpopo Province of South Africa operating on communal grazing lands with restrictions on the use of the common resource, earn more net farm income and invest in watering points than farmers operating on unregulated communal land (Anim and van Schalkwyk, 1996). This illustrates important implications for managing livestock production in communal grazing areas. The fact that 25 million of the world’s pastoral population are found in Sub-Saharan Africa and derive their livelihood directly from communal land use (Swallow, 1994), necessitates research to evaluate the relevant policy interventions.

5.3 Livestock Production Systems

Livestock production systems have been classified as grazing, mixed and industrial systems based on their management practices and the environment in which livestock are raised (Seré et al., 1996; de Haan et al., 1997; Blench et al., 2003; Otte and Chilonda, 2003). In the dry areas, pastoral and agropastoral systems evolved as the most effective way to utilise vast rangelands. Mortality of herds is high during severe droughts, but numbers are restored quickly after periods of adequate rain. In the margins between the wetter (disease-ridden) and drier regions, population pressure on agricultural land has increased and mixed crop-livestock farming systems evolved as a result (Winrock, 1992). For the purpose of this review, industrial systems will not be discussed. In Figure 5.1, the livestock systems development pathways are presented:

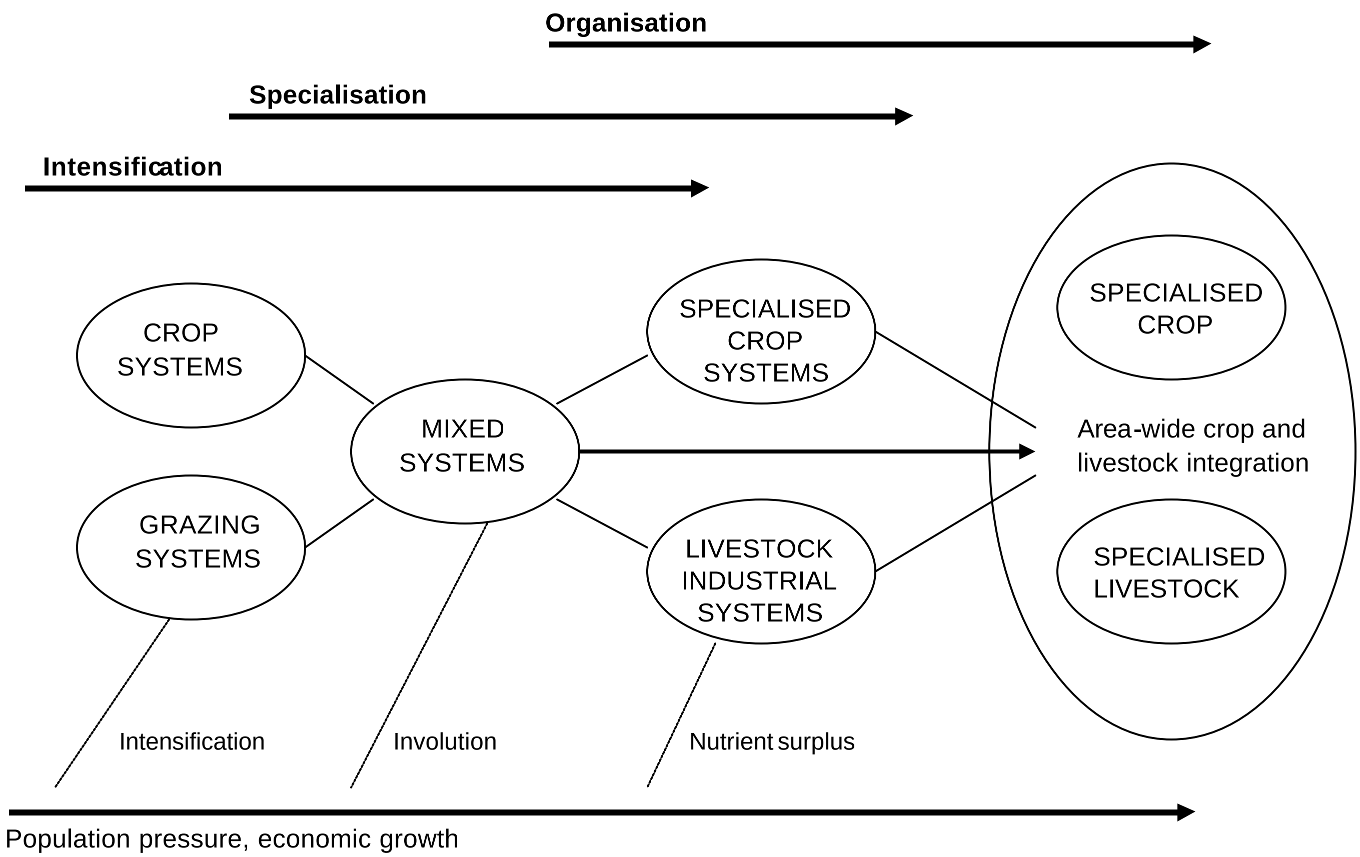

Figure 5.1 Livestock Systems Development Pathways (Steinfeld et al. 1997)

The different phases of the Livestock Systems Development Pathways can be characterised into intensification, specialisation and organisation. The interaction between the environment and livestock production factors (refer to sections 5.3.1 and 5.3.2), coupled with other factors such as access to markets, creates development opportunities as well as challenges for sustainability. These interactions, indicated by the dotted lines, include (Steinfeld et al., 1997):

- nutrient surplus (as a result of human population pressure and livestock density, access to markets and feed and incentive policies, aggravated by lack of regulatory responses)
- involution (where the balance between nutrients and farm power creates a widening deficit as a result of degrading natural resources), and
- intensification (balancing the pressures of human population growth with absorptive capacity by introducing new technologies).

In Table 5.1, the estimated distribution of ruminant livestock in sub-Sahara Africa, by agro-ecological zone, is illustrated. More than 50% of all ruminant livestock in Sub-Saharan Africa are found in the arid and semi-arid zones, with small ruminants as the lead species (Table 5.1). Although the lower rainfall areas in the semi-arid zones (500 mm – 700 mm per year) are best suited for grazing, livestock production in this zone is usually a component of mixed smallholder crop-livestock systems (refer to section 5.3.1). Cattle are the lead species in the semi-arid zone (30.6%). In the sub-

Table 5.1 Estimated Distribution of Ruminant Livestock ('000) by Agro-ecological Zone (AEZ) in Sub-Saharan Africa, 1999 (adapted from Otte and Chilonda, 2003)

AEZ	Cattle (Number)		Sheep (Number)		Goats (Number)		TLU*	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Total**	**%**
Arid	39 609	20.7	53 476	33.7	69 557	38.2	40 029	23.8
Semi-arid	58 552	30.6	36 338	22.9	47 889	26.3	49 409	29.4
Sub-humid	43 436	22.7	22 850	14.4	30 044	16.5	35 694	21.2
Humid	11 672	6.1	13 171	8.3	17 116	9.4	11 199	6.7
Highland	38 078	19.9	33 006	20.8	17 116	9.4	31 667	18.8
Total	191 347	100.0	158 841	100.0	182 086	100.0	168 019	100.0

** in Total Livestock Units (TLU): cattle = 0.70, sheep and goats = 0.10*

humid zone, livestock production is part of mixed crop-livestock systems. Again, cattle are indicated as the predominant species.

Although the humid zones (especially central Africa) constitute more than 20% of the surface area of Sub-Saharan Africa, livestock production is not an important economic activity because of disease. In the highlands which have the highest density of humans and animals, livestock usually are kept on smallholder crop-livestock farms (Blench et al., 2003).

5.3.1 Grazing Systems

Grazing systems in the developing world provide nine percent of the world meat production from cattle and 30% of the world's production of sheep and goat meat (de Haan et al., 1997). For almost 100 million people, grazing cattle is their only means of livelihood. In grazing systems, livestock provide a means of transferring nutrients across space and time (Tarawali et al., 2001). Interactions are very dynamic in these systems and include interplay between climate, soils, vegetation, human and livestock factors. The major feed source is usually from natural grasslands with some crop residues, implying that there are interactions between land, water, plants and animals.

Grazing Systems in Arid Areas

At present, the integrity of the rangeland systems of livestock production in the arid zones is threatened by high human populations (in relation to carrying capacity), increased cultivation, and the cutting of the few trees for fuel. Not only livestock is affected; severe land degradation and a decrease in soil fertility are taking place (Winrock, 1992; Scherr, 1999). However, the effects of livestock on the soil of grazing systems can be beneficial or detrimental, depending largely on management practices that dictate the resultant stocking densities (CAST, 1996; Powell et al., 1996; Hiernaux et al., 1998; 1999; Collins and Qualset, 1999). In functional pastoral systems, animals and people are highly mobile and contribute to efficient vegetation management, thereby preserving biodiversity and land resources (Schoonmaker-Freudenberger et al., 2000). To make optimal use of the heterogeneous landscape, pastoralists avoid risks by moving herds and flocks, and destock and restock in response to droughts. In this way, they employ various strategies to support their livelihood (Scoones, 1995).

Communal grazing areas are important sources of livestock feed in developing countries, but there is a common perception that grazing systems lead to desertification (UN, 1977; FAO/UNEP, 1984). This is true under heavy stocking rates and unsustainable land use practices (de Haan et al., 1997). However, in many parts of West Africa (Mali, Burkina Faso, Nigeria, Niger and Chad) the reversible expansion and contraction of the savannah is a natural phenomenon that may be influenced by pastoral systems (Nelson, 1990; Tucker et al., 1991). The amount of protein per hectare in traditional pastoral systems in Mali and Botswana is very high, even when compared to the same environments in Australia and the USA (Breman and de Wit, 1983; de Ridder and Wagenaar, 1984).

There is substantial evidence that arid areas are resilient and dynamic with a strong capacity to regenerate when rain returns (Thomas and Middleton, 1994). Coupled with the sustainable natural resource management and land use practices of most pastoralists, abiotic factors such as rainfall, not livestock density, determine long-term production and vegetation cover (Mearns, 1996).

Grazing Systems in Semi-arid and Sub-humid Areas

In Sub-Saharan Africa, the semi-arid and sub-humid areas are generally found in parts of the Sahel in West Africa, and in Southern and Eastern Africa. In Tanzania for instance, these areas cover 65% of the country where 30% of the human population and 59% of the livestock population live (Bureau of Statistics, 1995). In contrast to the arid systems where water availability dictates the productivity of the system, land, water, soil and biodiversity all influence productivity. More rainfall is available, and there is less disequilibrium with feed resources, although in many of the semi-arid areas, variation in rainfall still constrains production. However, pressure on the land mounts in areas with adequate and reliable rainfall, leading to more cropping and more perennial grass and shrub species that are in some cases less resilient than annual species. In Mali, where the percentage of bare soil increased by ten percent from 1950 to 1990, land degradation is significantly greater in areas with higher rainfall (Mainguet et al., 1992). In the sub-humid areas of Uganda, some of the highest rates of nutrient depletion in Sub-Saharan Africa have been found, with average annual losses of more than 70 kg of nitrogen, phosphorous and potassium per hectare (Stoorvogel and Smaling, 1990). In humid environments, disease tends to be more prevalent and affects livestock production. In these areas, the extremely high population pressure also leads to low productivity due to the very small areas available for cultivation and for keeping livestock.

Population growth and the prevalence of poverty are two major factors that contribute to land degradation and loss of biodiversity (de Haan et al., 1997). One of the most direct causes of land degradation is overgrazing by the prevailing sedentary livestock production systems. Oldeman et al. (1991) has estimated that overgrazing causes 35% of land degradation, whereas agricultural activities and deforestation is responsible for 28% and 35%, respectively. Mixed grazing is an important tool to increase the total output of animals per unit area. This higher yield occurs due to the increased efficiency of use of the available biomass, provided that there is an appropriate mix and number of different animal species (Devendra, 2001). Heavy livestock grazing in open savannahs leads to the disappearance of the most palatable grass species. This stimulates the growth of woody plants. Because these species can no longer be grazed effectively, initial bush encroachment sets in, with increased biomass production, and the diversity of plant and animal species declines. However, there are many cases in which plant biodiversity is increased in well-balanced grazing systems (Milchunas and Lauenroth, 1993).

5.3.2 Mixed Farming Systems

Section 5.3.1 confirms that animals are an important component of agricultural systems in Sub-Saharan Africa. Provided that rainfall is adequate, smallholders can intensify their systems by moving from pure grazing systems to mixed farming systems to diversify production and increase income. This change affects natural resource use and management. The integration of crop-livestock systems in smallholder farming systems is also well-developed in Asia. Between 70% and 95%

of ruminant livestock are found on mixed farms in rainfed areas in the different Asian countries (Devendra and Thomas, 2002).

McIntire et al. (1992) described the evolution of crop-livestock intensification based on the relationship between population pressure and an evolving role of livestock. To meet food needs, more land is devoted to crops, decreasing the amount of pasture and fallows which maintain soil fertility. In environments suitable for livestock, animals are confined and manure is collected and used as a soil amendment. As population pressure further increases, farmers find that they are forced to use technology more intensively. More manure is applied to maintain or increase production. In order to obtain more manure, they shift from paddocking to systems of collection, processing, and incorporation. Subsequently there is a shift from livestock systems that are based on field grazing of crop residues and pastures to systems where animals are confined and an increasing amount of residues are harvested and preserved. This results in a more intensive use of these products and more efficient use of animal wastes. In the systems described above, manure utilisation depends on the nature of the farming system. In integrated systems where the use of manure is already significant, the challenge is how to improve the efficiency of nutrient cycling. In systems where pastoral and settled farmers share a common environment, such as in Mali and Nigeria, exchange of manure for crop residues and water is common (Scoones, 1995). These manure contracts between pastoralists and farmers should ensure that both groups benefit economically (Powell, 1986 and Mortimore, 1991 as cited in de Leeuw et al., 1993).

Eventually, where farm size permits, hand labour is replaced by animal traction and mechanisation, which has become economical as a result of the high level of intensity of land use that has been achieved. In areas where climatic conditions allow, farmers begin to grow legumes and forages specifically to enhance the productivity of their livestock. This in turn increases soil fertility and crop yields. According to Delgado (1989), “this leads to the general hypothesis that mixed farming is a practice that permits higher labour inputs per unit of land in a profitable manner”. For instance, in Burkina Faso, the net crop income per peak labour hour of farmers using animal traction was 28% higher than the income of farmers using hoe cultivation.

Mixed farming systems contain 67% of the cattle and 64% of the small ruminants in the developing world. Almost 65% of the rural poor rely on mixed farming systems for their livelihoods and it is the main farming system in Sub-Saharan Africa (de Haan et al., 1997), found predominantly in Eastern (Ethiopia, Kenya, parts of Uganda and Tanzania) and Central (Rwanda, Burundi and parts of Zaire) Africa (Seré et al., 1996). In these systems, livestock and crops are produced within the same farming unit. This forms an almost closed system, as the waste of one system serves as the resource for the other i.e. manure from livestock is used to enhance crop production, while crop residues are used as supplemental feed for the animals (Nicholson et al., 2001; Tarawali et al., 2001). In Tables 5.2 and 5.3, the main interactions between crop and livestock systems in Sub-Saharan Africa are summarised and described:

Table 5.2 Summary of the Main Interactions between Crops and Livestock in Sub-Saharan Africa (adapted from Jahnke, 1982, ILCA, 1979 and McIntire et al., 1992, as cited in Otte and Chilonda, 2003)

		Zones				
		Arid	**Semi-arid**	**Sub-humid**	**Humid**	**Highlands**
Traditional Livestock Husbandry		Transhumance	Transhumance Agropastoral	Transhumance Agropastoral Sedentary	Sedentary	Sedentary
Crop Livestock Interactions	**Animal power**	n.a.	Moderate to high	Little to moderate and expanding	Little or none	Moderate to high
	Use of manure	n.a.	Little to moderate	Moderate to high	Little or none	Moderate to high
	Crop residues	n.a.	Moderate to high	Little to moderate	Little or none	Little to moderate
	Sown forage	n.a.	Little or none	Little but expanding	Little or none	Moderate to high

Table 5.3 Description of the Main Interactions between Crops and Livestock (adapted from Devendra and Thomas, 2002)

Main Interactions	
Crops	**Animal production**
Crops provide a range of residues and by-products that can be utilised by ruminants. Native and improved pastures and cover crops provide grazing for animals. Systems like alley cropping can provide tree forage for ruminants.	Large ruminants provide power for operations such as land preparation and for soil conservation practices. Ruminants provide manure for the maintenance and improvement of soil fertility. In many farming systems, it is the only source of nutrients for cropping. Sale of animals or hiring them out can provide cash for the purchase of fertiliser used in crop production. Animals grazing vegetation under trees can control weeds and reduce the use of herbicides in the farming system.

Several studies illustrate the importance of mixed farming systems. Increased population pressure resulted in intensification in cassava-livestock systems in seven Sub-Saharan African regions resulting in more positive nutrient balances and decreased nutrient losses (Christiaensen et al., 1995). In Rwanda, poverty and civil strife led to land scarcity and smaller farms. The absence or lower number of cattle on the land resulted in low crop yields in mixed systems. Farmers also reported that the main reason for the low yields was an absence of manure as fertiliser.

Mixed farming systems provide farmers with an opportunity to reduce risk by diversifying from single crop production, to use labour more efficiently, to have a source of cash to buy farm inputs and to add value to crops. Moreover, combining crops and livestock also has the potential to maintain ecosystem function and health and prevent agricultural systems from being too inflexible. Biodiversity increases, enhancing the capability of the system to absorb shocks to the natural resource base (Holling, 1995).

Farmers have incentives to manage natural resources, especially soil nutrients, responsibly, as the farmers' livelihoods depend on the preservation of these resources. Many studies in West and Central Africa, and the highlands of East Africa, have been conducted to illustrate the effects of nutrient cycling, soil structure, organic content and fertility management on the environment (Harris, 1998). Intensive, smallholder mixed farming systems in the East African highlands, where income from milk sales is used to purchase supplement feed for livestock, is reported by Lekasi et al. (1998). In this system, considerable attention is paid by farmers in the recycling of nutrients by fertilisation with manure and urine. In addition, land preparation with animals decreases the threat to biodiversity on marginal lands (Ehui et al., 1998).

However, there are exceptions to this balance in nature. In the highlands of Central Africa, as a result of over grazing, some of the most degraded land in the world is found (de Haan et al., 1997). Interplay between soil erosion and nutrient depletion is probably the most serious challenge facing mixed farming systems today, and related factors like cropping, fuel wood collection and grazing play pivotal roles. Thomas and Middleton (1994) reported that in Africa, 60% of the soil degradation occurs in the semi-arid and dryer sub-humid areas where mixed crop-livestock systems predominate. About 300 million hectares of soil has been severely degraded (high levels of soil erosion, nutrient depletion and desertification) (Pinstrup-Andersen and Pandya-Lorch, 1995). Almost 30% of the agricultural soil in Ethiopia has been lost over the past 35 years (Myers, 1986; Abbi, 1995). The economic losses due to soil erosion were estimated to be US$2 billion in the highlands of Ethiopia (Bojo and Cassels, 1995).

5.4 Environmental Impacts of Livestock Production

Livestock production has been linked to greenhouse gas emissions, deforestation, excess nutrients accumulating in the soil, water pollution and over grazing leading to erosion. However, the impact of livestock on the environment depends heavily on management practices and the nature of the agroecology. In some instances, the effect of livestock on the natural resource base is exaggerated (Ehui et al., 1998). For Sub-Saharan Africa specifically, the impact is very dependant on the amount of rainfall and stocking density. According to Nicholson et al. (2001), competition between wildlife and livestock may occur in semi-arid or arid areas. However, the nutrient patches left behind by migratory pastoralists can enhance wildlife habitat rather than degrade it.

Greenhouse Gasses

Livestock's relative contribution to global warming experienced implies that the changing weather patterns will have an adverse effect on agricultural production in the future. Greenhouse gasses (CO_2, CH_4, O_3 and N_2O) contribute towards global warming. For livestock in tropical production systems, the two main contributions to global warming are through carbon dioxide and methane emissions. Low quality forage contributes to these higher levels of emissions, and policy interventions through sustainable management practices within a reformed land tenure environment are required.

The burning of biomass is one of the main sources of global carbon dioxide (CO_2) emissions. Although forest destruction is the biggest contributor to CO_2 emissions, burning of savannah vegetation by herders during the dry season to grow new, palatable shoots, also contributes to some extent.

Livestock and manure management contribute 16% of the annual methane (CH_4) emissions in the world, which affect human and ecological health (USEPA, 1995). Conversion of fibrous grasses that are indigestible by humans to energy and high quality protein is directly linked to high CH_4 emissions. When fed low quality forage of sub-humid savannahs, acetate is the predominant fermentation end-product with the accompanying production of CO_2 and CH_4. Improving diet quality offers the opportunity to improve animal productivity and to reduce CH_4 emissions per unit of food produced (Nicholson et al., 2001).

Wildlife Interaction

Conflicts between wildlife and livestock are primarily based on access to grazing and water resources, with predation and disease a secondary, but very important, concern (Boyd et al., 1999). In many cases, conflicts between pastoralists and wildlife managers have increased because pastoralists have expanded beyond their traditional boundaries. However, in the rainforests and the moist sub-humid and humid lowlands of Central Africa, livestock numbers are still low due to tsetse infestation that influences the distribution of livestock in this area (Hall, 2001). In arid areas, like the north of Kenya, high numbers of livestock around watering points and settlements can exclude wildlife from their habitats and environments crucial for survival (Grandin et al., 2001). Blocking of migratory pathways is also an important consideration. Plant biodiversity can also be severely affected, due to trampling caused by heavy livestock numbers, and smaller wildlife populations are found around occupied settlements with large livestock herds (Geordiadis, 1987). Nicholson et al. (2001) found that in Botswana, the erection of fences for disease control inhibited the natural movement of wildlife, which in the 1980 drought led to the death of thousands of wildlife migrating to water points.

The issue of integrated wildlife management is an unfinished debate as socio-economic factors come into play. The beneficial effects of wildlife have been seen in game ranching, which is becoming increasingly important and has, in some instances, been shown to rehabilitate rangeland (Voeten, 1999). However, social infrastructure and even cash income, does not necessarily compensate for increased exposure to diseases, predation and crop pests.

The Role of Manure in Nutrient Cycling

The contribution of livestock through nutrient transfer and cycling is estimated at 20 million tons (20%) of the nitrogen and 11 million tons (40%) of the phosphorous fertiliser requirements of the world. Cycling of biomass through the faeces and urine (manure) of ruminant livestock from natural vegetation and crop residues is widely used in Sub-Saharan Africa to improve soil fertility (Powell et al., 1996; Snapp et al., 1998). This is a prerequisite for long-term sustainability, especially in the sub-humid areas where livestock pressures on land are high (Romney et al., 1994). The amount and composition of ruminant excreta are affected by type and stocking density of animals, the diet of the animal and the farming system they are raised in (pastoral, agropastoral or mixed crop-livestock) (O'Reagan and Schwartz, 1995; Mohamed-Saleem, 1998; Whitehead, 2000). In addition, production of faecal material is lowest in the dry season, depending on the agro-ecological area, and nitrogen and phosphorous levels in the diet are lower during the mid-dry season than in the early dry season or wet season (Powell et al., 1996; Mpofu et al., 1999).

A well-fed ruminant on a small farm in Southern Africa can produce close to two tons of recoverable manure in its lifetime when confined overnight (Schleik, 1986). In West Africa, sheep and goats produce on average 0.01-0.33 and 0.01-0.20 tons respectively (Fernandez-Rivera et al., 1993). For this example in West Africa, Powell et al. (1998) reported that for cattle, the estimated amounts of nitrogen and phosphorous that can be produced range from 12-17 and 1.5-2.1 $g.kg^{-1}$ respectively. Based on calculations of Jansen and de Wit (1996), between 40% and 120% of the phosphorous requirements per hectare for cassava can be supplied by livestock (this depends to a large extent on the plane of nutrition of the animal). This is an important factor as phosphorous and nitrogen are limiting nutrients in many parts of Sub-Saharan Africa with leached, aged soils and in humid areas (Powell et al., 1998).

Adding manure increases cation exchange capacity, and improves the stability of soil structure as it increases the water holding capacity. When pig and livestock manure are combined, it can contribute up to 35% of the soil organic matter requirements per hectare, relative to the amount needed in a specific environment (de Haan et al., 1997). Low soil organic matter is one of the major causes of poor fertility in sandy soils (Snapp et al., 1998).

In pastoral systems, livestock generally enrich rather than deplete biodiversity (Collins and Qualset, 1999). Nutrient rich acacia patches where Tswana cattle kraals were once located are found in nutrient poor savannah stretches in Southern Africa. Following abandonment, these kraals often support a unique plant community and potentially alter the spatial pattern of nutrient cycling within the ecosystem (Augustine, 2003). Reid and Ellis (1995) suggested that pastoralists in East Africa leave behind “nutrient hotspots” which are ideal for tree regeneration as they migrate.

Loss of Forest

Deforestation and loss of woodland have increased in Africa. Annually, three million hectares of forest and woodland in Sub-Saharan Africa are lost (Cleaver and Schreiber, 1994) and reforestation is far below the rate of deforestation (Paarlberg, 1995). Burning of forest and woodlands is widespread and uncontrolled, contributing to soil degradation, pollution and climate changes (Cleaver and Schreiber, 1994). The increasing absence of fuel wood leads to the greater use of manure and crop residues for fuel that can damage health and detract from soil fertility (Hutchinson et al., 1991).

The effect of livestock on deforestation is varied, as deforestation has many causes. In the eastern area of the Central African Republic, the incursion of Fulani pastoralists with their cattle into the tree parklands of the Zande people leads to (Carrera and Toutain, 1996, as cited in de Haan et al., 1997):

- increased openings in the forest cover
- a decrease in animal biodiversity
- degradation of the hunting potential of the Zande, and thus the quality of their diet, and
- loss of the traditional values of the Zande people.

On the other hand, examples exist where local communities share forests in a sustainable way. Farmers in the Kissidougou area of Guinea developed a symbiotic rainforest-livestock system. Livestock here are used to clear up undergrowth in the forest, which can then be used for fuel wood and shade for perennial crops. The population density has increased over the last two decades from ten to 60 persons per km^2. Here a positive relationship has emerged between population density and forest cover (de Haan et al., 1997).

5.5 Conclusions

The framework that emerges from this review is clearly one of urgency and complexity. The urgency stems from the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production. The complexity stems from livestock's use by smallholder agriculture for multiple needs, producing in the process multiple environmental benefits and costs. Moreover, livestock-environment interactions are typically second level problems, because it is not livestock per se, but the way in which livestock are managed and used by growing human populations that governs their impact on the environment. The purpose of livestock is determined by human needs, and technology translates these into different levels of natural resource use and sustainability.

It is important to keep in mind that there are large areas where livestock have remained in equilibrium with natural resources and, even more importantly, are contributing to maintain ecosystem health, biodiversity, flexibility and societal cohesion. Livestock and the environment can achieve a balance while at the same time fulfilling humanity's food needs and contributing to sustainable economic growth. This review also highlights that there are important situations where livestock are out of balance with the absorptive capacity of soil, water and air. Land degradation, deforestation, water pollution and greenhouse gas emission are the result, and in these areas urgent action is required.

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CHAPTER 6*

ASPECTS OF CATTLE PRODUCTION IN SMALLHOLDER FARMING SYSTEMS IN THE LIMPOPO PROVINCE OF SOUTH AFRICA

Abstract

Eighty-six smallholder cattle farmers in the Nzhelele District of the Limpopo Province of South Africa were surveyed. The farmers owned between one and 67 cattle, with an average of 10.3 head of cattle per household. The average age at first calving was 34.3 months. The rates of calving, weaning, calf mortality, herd mortality and offtake were 49.4%, 34.2%, 26.1%, 15.6% and 7.8% respectively. Contrary to the situation in many other regions of Southern Africa, commercial enterprise, not social prestige, constituted the main reason for farming with cattle. A marked complimentarity in resource-use i.e. crop residues as animal forage, has been demonstrated. It is concluded that cattle production in smallholder farming systems remain complex from a sociological, economic and ecological perspective.

Keywords: cattle, functions, productivity, smallholder, farming systems

6.1 Introduction

Overcoming malnutrition remains an illusive challenge facing humanity today. The threat of starvation is most serious in Africa, where an estimated 33% (138 million) of the population, mainly women and children, suffer from hunger (FAO, 2000). An

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Swanepoel, FJC, Stroebel, A, Pell, A and Groenewald, IB. 2004. Herd dynamics and productivity measures in smallholder cattle production systems in the Limpopo Province of South Africa. In: Wong, HK, Liang, JB, Jelan, ZA, HO, YW, Goh, YM, Panandam, JM and Mohamad, WZ (Eds). Proceedings of the 11th AAAP Conference. 5 – 9 September. Kuala Lumpur. Malaysia. 2:120-122.

estimated 680 million people keep livestock in developing countries, indicating the importance of livestock to their livelihoods (ILRI, 2000).

In South Africa, livestock production is a major component of rural agriculture. Livestock, particularly ruminants, provide households with a number of benefits, as presented in Table 6.1:

Table 6.1 A Summary of Benefits and Products Derived from Livestock (Pell, 1999; Swanepoel et al., 2000)

Benefit	Products
Food	Milk; meat; eggs; blood; fish; honey; processed products.
Clothing	Wool; hides; skins; leather.
Work	Draft power – cultivation; transport of goods and people; threshing; milling; pumping water.
Monetary	Capital wealth; investment; savings account; income from: hiring working animals; sale of products; sale of animals.
Social	Lobola (bride price); ceremonial; companionship; recreational; status.
Manure	Fertiliser (soil amendment); fuel; flooring.
Other benefits	Feathers; bone meal; soap production.

This diversity in benefits is erroneously viewed by many animal scientists as a negative factor in itself, responsible for low livestock productivity in communal systems. However, the multiplicity of purposes in keeping livestock could be viewed more positively as smallholder farmers making maximum use of their animals. This viewpoint is valid as long as a direct comparison between smallholder farmers and commercial enterprises is not made.

The objective of this paper is to investigate cattle production in the Nzhelele District of the Limpopo Province of South Africa.

6.2 Materials and Methods

Details regarding the study area, sampling procedures, questionnaire design, methods of data collection and data analysis are described in chapter two. For the purpose of this chapter, only a summary is provided.

The Study Area

The study was conducted in the Nzhelele Area in Ward 27 of the Makhado Municipality of the Vhembe District in the eastern part of the Limpopo Province. This area was part of the former Venda homeland. It is located at latitude 23^0 S and longitude of 30^0 E, at an altitude of 903 m. Average temperatures ranges between 15^0C and 26^0C. The mean annual precipitation is 780 mm, of which 80% occurs during the summer months (October – March). Eighty-six smallholder cattle farming households were selected for this study, out of a total of 189 households.

The Sample

A nonprobability sampling method was used to select a sample of 189 homesteads for the survey. Eighty-six of these kept livestock. The method of selection was based on the judgment of the researcher, with valuable input from the collaborating institutions and other local resources. The selection of the sample was purposive, as it was assumed that most of the homesteads in the selected villages were typical, based on previous studies in the area. A local South African non-governmental organisation (NGO) provided useful insights into the local population distribution and homesteads from which the sample was drawn.

Data Collection and Analysis

Methods of data collection included completion of a structured questionnaire, unstructured interviews, key informant interviews and focus group discussions. The survey collected information on socio-economic characteristics of the farmers, cattle production systems and cropping practices. Data analysis was performed using Statistical Analysis Systems (SAS) (SAS, 1990), and direct calculations. Analyses of data included herd size and composition, reproduction, herd mortality and offtake and choice of breed. Analyses of crop-animal interactions included main crops cultivated and methods and use of crop residues.

6.3 Results and Discussion

The herd structure and number of cattle, the herd size summary and efficiency parameters are illustrated in Tables 6.2, 6.3 and 6.4 respectively:

Table 6.2 Herd Composition (N = 888)*

Herd Class	Number	%
Cows	405	45.6
Bulls	136	15.3
Heifers	323	36.4
Steers	24	2.7
Total	888	100.0

*Unweaned calves were calculated with the total number of animals

Table 6.3 Herd Size Summaries (N = 86)*

Herd Size Category	Number of Households (N)	%
1 – 5	26	30.2
6 – 10	33	38.4
11 – 20	17	19.3
21 – 30	9	10.2
>30	1	1.1

Table 6.4 Efficiency Parameters

Factor	Time (months)	%
Age at first calving	34.3	
Calving rate		49.4
Weaning rate		34.2
Calf mortality		26.1
Herd mortality		15.6
Offtake		7.8

* The sample size differ i.e. 90 vs 86, as a result of the presence of statistical outliers

Herd Size and Composition

It is widely reported and accepted that the herd size and composition are regarded as one of the major constraints to increasing cattle productivity. The number of cattle owned varied from one to 67, with an average of ten (10.3) head of cattle per household. This figure is similar to that reported for other areas of South Africa. Moroosi (1999) reported that the average herd size in Thaba Nchu was 10.8. It is higher than Nthakeni (1996) who had a mean of eight cattle for farmers in Venda, and Bembridge (1984) who reported a mean herd size of six head of cattle in the former Transkei. It is significantly lower than the average of 29 reported by

Schwallbach et al. (2001) for farmers in the North West Province. According to the survey, 68.6% of the respondents owned ten or less head of cattle, with only one household owning more than 30 head of cattle.

Breeding females constituted the largest group of the herd (45.6%), which is in agreement with results of other studies in South Africa (Seobi, 1980; Dreyer et al., 1999; Moroosi, 1999; Swanepoel et al., 2000; Schwallbach et al., 2001). Replacement heifers constituted a large proportion of the herd (36.4% of the total herd and 44.4% of the females), while bulls constituted 15.3% and steers 2.7% of the total herd respectively. This low proportion of bulls and steers (18%) in relation to female animals (refer to table 6.2) suggests that bulls and steers are either sold for cash income, or slaughtered for home consumption. Assuming that steers are primarily used for animal traction, few animals are used for transportation or other agricultural activities. The bull to cow ratio was 1:3, while the bull to female ratio (cows and heifers) is 1:5, which is still extremely high in comparison with the low calving percentage.

Reproduction

The average age at first calving was 34.3 months, followed by a calving interval of 24 months, with a calving percentage of 49.4%. There is no distinct calving and breeding season: calves are born throughout the year with a peak during the summer months. The peak calving period during the summer is associated with the uni-modal rains, highly concentrated during December – February in this area. Consequently, two-thirds of cows calve from December – February.

The reproduction rate of cattle in this study (49.4%) is comparable to findings from other studies of smallholder production systems in Southern Africa where reproduction rates of between 40% and 50% have been recorded (du Casse, 1974; Seobi, 1980; Mdhluli, 1981; Tomo et al., 2000). It is also comparable to reproduction percentages reported in other studies in the region. About half of recorded calving rates from a representative sample of African production systems had a calving percentage of approximately 50% (de Leeuw and Thorpe, 1996). As cows rarely conceive within a year of calving, calving intervals of two years and longer are common. Extended drought periods which are common to this area contribute towards the low reproduction rates. The long calving interval could result from the fact that few farmers (two percent) wean calves. The remainder (98%) leave the calves with the dams until natural separation occurs. Other studies reported much lower reproduction rates, i.e. Steyn (1982) in the former Ciskei (31%) and Bembridge (1987) in the former Transkei (38%).

Milk Production

Despite the fact that most farmers milk their cows for home consumption, none of them indicated that this was the main reason for farming with cattle. Herd management, particularly milking strategies, may play a role in contributing towards the low reproduction rate, especially the longer calving interval. Milking strategies of herd owners are guided by a complex set of factors such as herd size, family subsistence needs and whether there is a market for milk. Within the herd, the yield potential of cows and the condition of the calves influences milking frequency and dairy milk production (Grandin, 1988). Within this study, herd size and cattle wealth (number of cattle per person) influences milk offtake, since milking is primarily focused on household food needs. Thus, the number of cows in milk is negatively correlated with milk offtake yield. The results of this study in a crop-livestock system have been substantiated by Coppock (1994) who reported that pastoralist households with only three cows extract 213 litres annually, compared to those with 28 cows who extracted only 70 litres of milk per lactation period. Although the systems are different, the fact that the number of cows in milk is negatively correlated to milk offtake yield remains. The reason being that milking is primarily focussed on the amount needed by the household.

Herd Mortality and Offtake

Herd mortality in this study is 15.6% which obviously represents a considerable loss to farmers and is twice the offtake percentage of 7.8%. However, in most cases, part of or the entire carcass of dead animals is consumed by the household. This high mortality rate could have been aggravated by the severe drought experienced during the year of the study in this area. Due to the fact that very few farmers keep production records of their herds, mortality rates of the different herd classes could not be calculated. However, it is well documented that mortality rates of lactating cows and calves increase significantly during multi-year drought periods, i.e. during the 1983 and 1984, drought losses of cows and calves in pastoral herds in Kenya and Ethiopia were severe: 40 – 50% in cows and as much as 65% of calves (Bekure et al., 1991 and Coppock, 1994). Similarly, in arid Zimbabwe during the 1991 – 1992 drought, 70% of the cows and 98% of the calves died or were disposed of through emergency sales or slaughter (Moyo, 1996). There was a significant difference ($p<0.01$) in mortality rate between cows with calves compared to dry cows, oxen and bulls. In extended dry periods and droughts, the probability of lactating cows dying is higher that for non-lactating cows. Cows which calve regularly remain in relatively poor condition and rarely have the opportunity to gain weight. During severe droughts therefore, highly fertile cows are at "high-risk". Non-lactating cows are "insurance" and enhance economic survival (Moyo, 1996).

The offtake rates of cattle under communal tenure is low in most reports [Tapson, 1982 (5.4%), Steyn, 1988 (7.5%)]. The offtake of the present study is 7.8%, which compares well with these figures. Fenyes (1982) reported low levels of cattle sales in the former Lebowa homeland of South Africa. In this study, 42% of the respondents did not want to sell cattle as they believe in maximising the number of cattle owned. Others felt that owning many cattle safeguards against losses during drought. This will not cause a total loss as they will use the meat for consumption purposes. It is clear that there is a need to encourage the communal farmer to increase offtake from their herd and to establish an appreciation of improved productivity and quality, instead of maximising animal numbers only (Bailey et al., 1999).

Choice of Breed

The most popular cattle breed was the Nguni which were 40% of the total, followed by the Afrikaner with 13% and the Bonsmara at five percent. The Nguni are believed to have superior adaptability under extreme environmental conditions. It is well known and documented that indigenous Sanga cattle breeds i.e. Nguni and Afrikaner are genetically well-adapted to the drought-prone environment (Tomo et al., 1998; 1999; 2000). Further, it is well documented that the Nguni is more fertile than the Afrikaner. The main reason for this is the fact that the Nguni has migrated south, along the east coast of Africa, with high rainfall and abundant feed supply. The Afrikaner, on the other hand, has migrated south along the dry and arid west coast of the continent. As a result, the Afrikaner has developed an inherent protective mechanism, whereby reproduction is suppressed in the face of limited feed supply (Hetzel, 1988; Tomo et al., 2000). Smaller body size is an adaptive attribute. A certain minimum level of adaptation is required for production under tropical and sub-tropical conditions.

Main Reasons for Farming with Cattle

The reasons for farming with cattle are illustrated in Table 6.5:

Table 6.5 Reason for Farming (N=141)*

Reason	N	%	Rank
Commercial purposes	72	51.1	1
Consumption	60	42.6	2
Social prestige	32	22.7	3
School and hospital fees	24	17.0	4
Lobola	14	9.9	5
Animal traction	7	5.3	6
Savings	7	4.9	7

***** Some respondents provided more than one motivation, therefore percentages add up to more than 100%.

Smallholder farmers in this region are more commercially-orientated than others in South Africa, where capital wealth, social prestige, consumption and lobola (bride price) are given as more important reasons for farming than are cash-related reasons. The results also confirm those of Wilson (1995), Nel (1998), Moroosi (1999), Swanepoel et al. (2000), Schwallbach (2001) and Swanepoel et al. (2002) who reported that livestock, especially cattle and their products, provide cash income and financial security for many smallholder farmers in Southern Africa. However, it would be difficult to determine which farmers actually sold their cattle, due to the fact that record keeping of the farming enterprise is extremely low. It may be postulated that herd size has an influence on sales. Although social prestige and capital wealth were only cited as the third-most important reason for keeping cattle, it confirms that there is a social-economic status related to the ownership of cattle. This is commonly referred to as the “cattle complex”, where cattle are kept for prestige and status and not for production (Mtetwa, 1978). The findings by Bembridge and Burger (1977) that socio-economic status can be regarded as being a very useful predictor of successful, progressive cattle farming is important in this analysis. Whilst Wilkering et al. (1962) defined social status as the ranking given to an individual based upon consensus of members of a community or society as to what they regard as “high” or “low” characteristics, it has been concluded from the Bembridge and Burger (1977) study that education, income, size of the enterprise, participation in village and district affairs, standard of living and a linkage to urban cities were identified as determining the socio-economic status.

This conclusion, and the fact that cattle farmers had high socio-economic status in their communities, emphasises the relationship between rural livestock production and social development. This analogy is logical because the production and consumption of animal products are not necessary for survival but add to the quality to life. Improvements in animal production have often been represented as one of the best avenues for raising the smallholder producer from the level of subsistence to that of a small commercial entrepreneur (Kadzere, 1996).

Crop-Animal Interactions

In Tables 6.6, 6.7 and 6.8, the main crops grown, uses for crop residues and methods for the use of crop residues are illustrated:

Table 6.6 Main Crops Cultivated (N=90)

Crop	N	%
Maize	53	58.9
Vegetables	15	16.7
Fruit	12	13.3
Other	10	11.1

Table 6.7 Use of Crop Residues (N=90)

Usage	N	%
Feed animals	34	37.8
Leave on field	41	45.6
Store for livestock	6	6.6
Other	9	10.0

Table 6.8 Methods of Using Crop Residues (N=90)

Usage	N	%
Cut and carry to animals	54	60.0
Send animals to graze in field	27	30.0
Store for cattle	3	3.3
Other	6	6.7

The integration of crop and animal production is well developed in farming systems in Southern Africa. The benefits of crop-livestock interactions are many. There is a marked complimentarity in resource-use in these systems, with inputs from one sector being supplied to others, such as draft animal power and manure for crop production and crop residues as feed for livestock. This is substantiated by results of the current survey, where 93.3% of the farmers indicated that they use crop residues for animal feed, either directly through the cut-and-carry system, by leaving it on the field for direct grazing or storing it for later use. The transfer of nutrients from grazing lands to crop lands through manure contributes considerably to the maintenance of soil fertility and the sustainability of the farming system (Powell et al., 1996). Livestock provide a least cost, labour efficient route to intensification through nutrient cycling. Keeping animals also provides a use for other resources, such as the crop residues, which might be wasted in the absence of animals. The main crop-animal interactions in mixed farming systems are described in Table 6.9:

Table 6.9 Description of the Main Crop-animal Interactions in Mixed Farming Systems (Devendra and Thomas, 2002)

Main Interactions	
Crops	**Animal Production**
Crops provide a range of residues and by-products that can be utilized by ruminants. Native and improved pastures and cover crops provide grazing for animals. Systems like alley cropping can provide tree forage for ruminants.	Large ruminants provide power for operations such as land preparation, and for soil conservation practices. Ruminants provide manure for the maintenance and improvement of soil fertility. In many farming systems, it is the only source of nutrients for cropping. Sale of animals or hiring them out can provide cash for the purchase of fertilizer used in crop production. Animals grazing vegetation under trees can control weeds and reduce the use of herbicides in the farming system.

6.4 Conclusion

The measures of productivity of cattle in this study are generally low with respect to reproduction and offtake percentages and high in terms of mortality. The word “production” is relative, especially when comparing two systems which from the outset have different objectives, as is obviously the case between smallholder communal and commercial producers in South Africa. Contrary to the situation in many other Southern African regions, social prestige did not constitute the main reason for farming with cattle, but cattle were reared for commercial purposes. The Nguni was the most popular cattle breed. A marked complimentarity in resource-use i.e. crop residues as animal forage, has been demonstrated. The remark by Little (1980) remains highly appropriate: “*There are few development issues today which entail a greater complexity of sociological, economic and ecological variables than that of livestock in Sub-Saharan Africa*”.

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CHAPTER 7

CATTLE HERD- AND GOAT FLOCK SIZE IN RELATION TO HOUSEHOLD FARM RESOURCES IN MIXED FARMING SYSTEMS

Abstract

A survey was conducted using a sample of 86 smallholder cattle farmers in the Nzhelele District of the Limpopo Province of South Africa, all of whom own cattle and goats. Family size is the single most important factor among all variables studied (farm size, grazing land area, cultivated area and maize production area) that influences herd size for cattle and goats. The most important factor limiting the amount of land cultivated and the area used for maize production is farm size. Farm size has no relationship to the number of cattle or goats owned, as livestock predominantly depend on communal grazing. Animal traction supported by family labour, played a prominent role in land cultivation, due to the small farm size.

Keywords: livestock, mixed farming systems, maize

7.1 Introduction

Mixed farming systems provide 50% of the world's meat and 92% of the milk to world livestock products (de Haan et al., 1997; Cast, 1999; Swanepoel et al., 2002), and contain 67% of the cattle and 64% of the small ruminants in the developing world. Almost 65% of the rural poor rely on mixed farming systems for their livelihoods, and it is the main farming system in Sub-Saharan Africa (de Haan et al., 1997), found predominantly in Eastern (Ethiopia, Kenya, parts of Uganda and Tanzania) and Central (Rwanda, Burundi and parts of Zaire) Africa (Seré et al., 1996). Mixed farming systems exploit the complimentarity between livestock and crop production (Nicholson et al., 2001; Tarawali et al., 2001). Because crop harvests are seasonal, livestock ensure the availability of food and income to smallholder farm families throughout the year. Livestock also supply draft power and manure as direct contributions to crop production while crop farming supplies crop residues as feed to livestock, and plays an important role as a major source of cash income to smallholder farmers. However, livestock may compete with crop farming for resources such as capital, land and labour. It is important to exploit the complimentarity between livestock and crop farming in mixed farming systems through sustainable improvements. The definitions and philosophy of sustainability are numerous; however, the operational aspect of sustainability still remains a major challenge (Udo and Cornelissen, 1998). Various definitions of sustainability exist, but there is agreement that in relation to smallholder farming systems, sustainable agriculture is ecologically sound, economically viable and socially just over time (Samdup and Udo, 2004). Sustainable improvement of livestock production cannot be achieved without understanding the farming system of which it is part. It is also important to ensure that any attempt to improve livestock production should be aligned, and be in support of, the farm household objectives.

Knowledge of the resource-base of the farming household and the likely relationship of these resources should contribute to the understanding of the dynamics of the smallholder production system. Therefore, the main objective of this study is to assess relationships between family size, farm size, grazing land area, cultivated area and maize production area, with cattle herd and goat flock size of smallholder farmers in the Limpopo Province of South Africa.

7.2 Materials and Methods

Details regarding the study area, sampling procedures, questionnaire design, methods of data collection and data analysis are described in chapter two. Only a summary of this information is provided in this chapter.

Study Area

The study was conducted in the Nzhelele Area in Ward 27 of the Makhado Municipality of the Vhembe District in the eastern part of the Limpopo Province. This area was part of the former Venda homeland. It is located at latitude 23^0 S and longitude of 30^0 E, at an altitude of 903 m. Average temperatures range between 15^0C and 26^0C. The mean annual precipitation is 780 mm, of which 80% occurs during the summer months (October – March). Eighty-six households involved in smallholder farming with cattle were selected for this study, out of a total of 189 households in the Nzhelele District of the Limpopo Province of South Africa. The methods of data collection included completion of a structured questionnaire, unstructured interviews, key informant interviews and focus group discussions. The survey collected information on socio-economic characteristics of the farmers, cattle production systems and cropping practices.

The Sample

A nonprobability sampling method was used to select a sample of 189 homesteads for the survey. Eighty-six of these kept livestock. The method of selection was based on the judgment of the researcher, with valuable input from the collaborating institutions and other local resources. The selection of the sample was purposive, as it was assumed that most of the homesteads in the selected villages were typical, based on previous studies in the area. A local South African non-governmental organisation (NGO) provided useful insights into the local population distribution and homesteads from which the sample was drawn.

Statistical Analysis

To examine the existence and magnitude of association between farm resources and livestock data, partial correlation analysis was completed (SAS, 1990). Analysis of variance was performed using Statistical Analysis Systems (SAS) (SAS, 1990). The statistical model for the analysis of data on cattle herd size and goat flock size (dependent variables) included the main effects of family size, farm size, grazing land area, cultivated area and maize area cultivated (independent variables) (Raubenheimer, 2005). For the analysis of data on cultivated area and maize area cultivated, homesteads were divided into smaller or larger groups. This differentiation is based on the size of the cattle herd or goat flock kept, i.e. cattle herd size and goat flock size, as well as all other variables, including family size and farm size, are categorized as *large* when they were larger than their respective means and *small* when they were smaller or equal to their respective means. Livestock herd size and goat flock size were described in numbers of animals, because of the general uniformity in size of the animals.

7.3 Results and Discussion

Farm size of the surveyed households varies between 0.1 and 4.5 ha with a mean farm size of 1.3 ha. The grazing area per village ranges between 5 and 30 ha, with a mean of 18.2 ha. Family size ranges from one to 13 persons, with an average of six persons per family. All households keep cattle and goats. The mean herd size for cattle was ten (10.3), ranging between one and 30. One farmer owned 67 head of cattle. The mean flock size for goats is eleven, ranging between three and 59.

The partial correlation coefficients (r) and mean squares for cattle herd size and goat flock size are presented in Table 7.1. Least square means and standard errors (SE) for area cultivated and area of maize produced are presented in Table 7.2:

Table 7.1 Partial Correlation Coefficients (r) and Mean Squares for Cattle Herd Size and Goat Flock Size

		Cattle Herd Size[1]		Goat Flock Size[1]	
Source of Variation	***df***	**Mean Square**	**r**	**Mean Square**	**r**
Family Size (persons)	1	5.34*	0.50*	3.09**	0.45**
Maize Production (ha)	1	0.20	0.10	0.01	0.09
Farm Size (ha)	1	0.04	0.08	0.72	0.14
Grazing Land Area (ha)	1	0.80	0.19	0.11	0.07
Cultivated Area (ha)	1	0.37	0.17	0.25	0.12
Residual	80	0.34	-	0.26	-

**P<0.05; **P<0.01; [1]Includes cattle and goats because of the general uniformity in size of the animals*

Table 7.2 Least Square Means and Standard Errors (SE) for Area Cultivated and Area of Maize Cultivated

			Area Cultivated (ha)		Maize Cultivated (ha)	
Source of variance	**Division**	**Number of Homesteads**	**Least Square Mean**	**SE**	**Least Square Mean**	**SE**
Overall Mean		86	3.31	0.37	8.60	0.38
Family size (persons)	1-6	42	3.92[a]	0.49	9.56[a]	0.50
	7-13	44	2.69[a]	0.47	7.64[a]	0.46
Farm size (ha)	0.1-1.3	61	0.56[a]	0.27	2.09[a]	0.27
	1.4-4.5	25	6.05[b]	0.80	15.11[b]	0.80
Cattle herd size (number)	1-10	47	3.61[a]	0.54	9.46[a]	0.53
	11-30	39	3.01[a]	0.43	7.74[a]	0.44
Goat flock size (number)	3-11	53	3.58[a]	0.44	8.62[a]	0.45
	12-59	33	3.03[a]	0.54	8.58[a]	0.53

Means in each class indicated by different letters differ (P<0.01)

Effect of Family Size on Herd and Flock Size

The size of the goat and cattle herds was positively correlated with family size. Table 7.1 also shows that family size had a highly significant effect (P<0.01) on cattle herd size and a significant effect (P<0.05) on goat flock size per farm. None of the other factors affected either cattle or goat herd size.

The increases in cattle and goat herd sizes per farm as family size increased may reflect a strategy to provide employment for children and older members (especially women) of the extended families. Further, a larger number of cattle and goats serve as security which can be converted into cash to pay for school fees and other household expenses by large families. This is possible, as the available grazing area is relatively large (an average of more than 18 ha per village) compared to the Kenyan highlands, were the grazing areas is limited, resulting in adoption of zero-grazing practices (Mucuthi et al., 1994). According to Swanepoel et al. (2000), labour for livestock production in the former Venda area of South Africa is mainly supplied by female and child labour, who have limited employment options. A similar observation has been made by Gryseels (1988) with respect to labour inputs in livestock production in the Ethiopian highlands that was substantiated by Quinsimbing (1994). It is also likely that the labour requirements for maize and other food crops are low in the present study, since the potential for conflict of labour needs for livestock and crops are different with respect to seasonality, intensity and frequency. As there were no grazing restrictions, farmers in the present study area probably kept as many animals as possible, provided that the household benefited from the increased herd size. The grazing area per village ranges between five and 30 ha, with a mean of 18.2 ha. This is substantially higher than what was found in other studies in Kenya (Mucuthi et al., 1994), where the available grazing area is highly limited, resulting in the widespread adoption of zero-grazing.

As indicated, livestock are kept to increase the flexibility with which money can be made available to meet immediate family needs. As the area to produce maize is limited (mean of 1.3 ha), and there is no significant difference between large and small families in the area of maize cultivated, livestock remain the most viable alternative for farming families to meet their household requirements. This has been substantiated by Dibissa and Peters (1999) who concluded that farming family size was the single most important factor affecting cattle herd size.

Effect of Farm Size and Grazing Area on Cattle Herd and Goat Flock Size

Farm size and grazing land area did not affect ($P>0.05$) the number of cattle or goats kept. This is due to the availability of communal grazing lands, ranging between 5 and 30 ha, with a mean of 18.2 ha. These results are in agreement with Dibissa and Peters (1999) who found no significant correlation between individual landholding or grazing land size and the number of livestock in the Ethiopian highlands. Similarly, Mucuthi et al. (1994) reported no relationship between landholding size and herd size in west Laikipia, Kenya. These authors stated that grazing land area tends to be determined by the area reserved for crop production, rather than vice versa. In the present study, cattle and goat herd sizes are more closely correlated with communal grazing area than with farm size. This is explained by the fact that adequate size communal area is available for grazing.

Area Cultivated and Area of Maize Production

Total area cultivated and the amount of land used for maize production per household were significantly influenced ($P<0.01$) by farm size (Table 7.2). Animal traction is used to some extent by smallholder farmers in this region. On small farms or on those without oxen, family labour was used rather than draft animals, as the opportunity costs were lower than hiring oxen for draft power.

7.4 Conclusion

Family size is the single most important influence on number of cattle and goats kept among all factors studied. The most important factor limiting the total amount of land cultivated and the area planted with maize is farm size. Farm size has no relationship with number of cattle or sheep raised, as livestock predominantly depends on communal grazing. Due to adequate availability of communal grazing land area, with no restriction on access, farmers kept as many animals as possible. As the farm sizes were very small, animal traction (to a small extent), mainly supported by family labour, played a prominent role in land cultivation.

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CHAPTER 8

ISSUES AND IMPLICATIONS FOR LIVESTOCK DEVELOPMENT POLICIES IN EASTERN AND SOUTHERN AFRICA

Abstract

Empirical studies and reviews from Eastern (Kenya) and Southern (South Africa) Africa have been used to construct a policy framework to guide livestock development in these two regions. Five overarching, integrated elements have been identified. These include food production and security, capacity strengthening for livestock research, livestock and the environment, health and genetics and marketing of livestock and livestock products. The framework that emerges is complex, due to the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production.

Keywords: livestock, smallholder development, policy framework

8.1 Introduction

Sub-Saharan Africa has often been regarded in the development field as a homogenous entity with common problems that require similar strategies. Most countries in Sub-Saharan Africa became independent in the early 1960's, but the process of developing agricultural strategies started much earlier. Agriculture plays a significant role in overall development strategies on a continent where, on average, agriculture accounts for 70% of employment, 40% of exports and 33% of Gross Domestic Product (GDP) (Delgado, 1997a). Evidence from elsewhere in the world, and more particular from elsewhere in Africa, overwhelmingly demonstrates that smallholder agriculture has been the principal economic driver in rural areas and that smallholder agricultural units have been far more productive over time than large-scale, commercial operations, based on output per unit labour (Delgado, 1997b).

Livestock production systems play an important role in the agricultural economy of Sub-Saharan Africa. Agriculture contributes between four percent and five percent to the GDP in South Africa, while it contributes 27% to the GDP in Kenya (Kajume and Muthee, 1998; Stroebel, 2000). Livestock and related products are the major contributors to these figures. Apart from this contribution, the many benefits from livestock and related products are summarised in chapters one and four. Nevertheless, there is considerable potential for improving these systems and further enhancing the contribution of livestock to food and livelihood security.

This chapter focuses on the implications for research and development in Sub-Saharan Africa, based on the findings and analyses from the previous chapters. It includes discussion of the development of livestock policies, the major similarities and differences between South Africa and Kenya, and critically examines the research framework and institutional support required for a comprehensive livestock policy with an emphasis on smallholder systems.

8.2 Materials and Methods

The Study Areas

The Nzhelele Area is located in Ward 27 of the Makhado Municipality of the Vhembe District in the eastern part of the Limpopo Province. This area was part of the former Venda homeland. It is located at 23^0 S latitude and 30^0 E longitude, and has an altitude of 903 m. The area is close to the borders of Zimbabwe and Botswana. The population of the Makhado Municipality is estimated at 500 000 people, of whom approximately 11 300 reside in the Nzhelele Area (StatsSA, 2003). The education level is very low, with more than 26% of the population having less than a primary education level (Standard Five/ Grade Seven). Of the total labour force, 41% of the population is involved in formal agricultural activities. Average temperatures vary between 15^0C and 26^0C. The mean annual precipitation is 780 mm, of which 80% occurs during the summer months (October – March). Livestock and crop farming are the predominant forms of agriculture, practised by approximately 50% of the population in the area (Acheampong-Boateng et al., 2003). Smallholder farms are located throughout the Nzhelele Area, characterised by low levels of productivity and holdings of approximately 1.5 ha per farmer, although this figure varies greatly. Production is primarily for subsistence purposes with little marketable surplus, a situation that farmers and government would like to change.

Baringo is one of the 14 districts in the Rift Valley Province of Kenya. It borders Turkana and Samburu districts to the north, Laikipia to the east, Nakuru and Kericho to the south and Uasin Gishu, Elgeyo Marakwet and Pokot to the west. The district is located between longitudes 35^0 30' and 36^0 30' E and between latitudes 0^0 10' S and 140' N. It is cut by the Equator at the southern tip at Mogotio Town. The district covers an area of 10 949 km^2 (Kenyaweb, 2001). It is estimated that Baringo District has a population of 242 000 people, with a high annual average growth rate of three percent (Central Bureau of Statistics and ILRI, 2003). The range of people falling below the Kenyan poverty line of US$ 0.53 per day is between 29% and 73%, for a district mean of 46%. This variation is based on the presence of an irrigation scheme, as well as the irregular rainfall, negatively influencing the livelihood of a large part of the population in the area. The district, as the country, has a very youthful population, with 50% falling in the age category 0-14 years. There are approximately 72 000 households, with an average of five people per household. Baringo District has an arid to semi-arid climate, with variations depending on the topography. Rainfall varies between 600 mm to 1500 mm, with 50% reliability. Livestock production activities are throughout the district, but predominantly in the upper and lower midlands (Kenyaweb, 2001).

Data Collection and Sampling

A nonprobability sampling method was used to select a sample of 189 homesteads for the survey in South Africa (Byerlee and Collinson, 1984). The selection of the sample was purposive, as it was assumed that most of the homesteads in the selected villages were typical, based on findings of previous studies in the area. A local South African non-governmental organisation (NGO) provided useful insights into the local population distribution and homesteads from which the sample was drawn. Methods of data collection included completion of a structured questionnaire, unstructured interviews and observation. Field notes were written and analysed. In the case of the Nzhelele Area, key informant interviews, focus group discussions and homestead surveys were conducted. In Baringo District, key informant interviews and focus group discussions were held. Due to the general nature of the data collection in the Baringo District, key informant interviews were the only source of primary data, all the other data were collected from secondary sources. Interviews were organised based on the knowledge of the respondent of livestock systems and policy issues in Kenya. In addition, an experienced extension officer was recruited to provide detailed information on the Baringo District.

Quantitative research was used to address questions that were predominantly based on the descriptive and some of the theoretical objectives of the study. For instance, data on herd dynamics and productivity measures of livestock within the farming system in the case of South Africa were studied using a quantitative approach. In contrast, a more qualitative research framework was used to address the theoretical and applied objectives. In addition, qualitative approaches were used to collect sensitive data, such as gender roles, income and assets (i.e. herd size). However, an integration of research methods, based on either simultaneous or sequential combinations of quantitative and qualitative data and techniques, was used to address the research questions. During the field research (orientation, key informant interviews, focus group discussions and individual interviews), additional research tools including a comprehensive literature review, personal observations, field notes and unstructured interviews were used to supplement the main instruments.

8.3 Results and Discussion

8.3.1 Livestock Policies in Southern Africa: South Africa

The dual structure of agriculture in South Africa and the comparatively low productivity of smallholder farmers is not the result of economies of scale in the large farm sector, but rather of decades of Government policy guided by the general political and economic philosophy of white domination known as apartheid. Agricultural development of the traditional black reserves (Bantustans, homelands etc.) was also not a priority in South Africa's economic development plan. These areas were rather viewed as "labour reservoirs" for South Africa's industrial development.

Different policies applied to commercial agriculture and to black smallholder farmers in the former "homelands". Three clearly articulated approaches to agricultural development in the former homelands can be identified: 1) betterment planning to the late 1970's, 2) centrally managed project farming, and 3) farmer settlement projects during the 1970's and 1980's. This was followed by the more broad-based farmer support programmes (FSP) supported by the Development Bank of Southern Africa (DBSA) during the 1990s (Ellis-Jones, 1987; Christodoulou and Vink, 1990; Bromberger and Antonie, 1993; van Rooyen, 1993).

However, very little have changed in terms of improved equality and improved living conditions for the rural poor. There are still distorted land, labour, output and input markets and a skewed pattern of infrastructure, provision and service supply systems still exist. The unequal ownership of land and the effects of the past policies still remain. Unless this is changed, it is unlikely that the conditions of the poor, many of whom reside in rural areas, will improve (Thirtle et al., 2000).

Current legislation to improve livestock production cannot meet the needs of both the commercial and resource-poor sectors. Therefore, a holistic, national livestock development strategy is being developed. It is based on the *Presidential Imperatives* and the *Strategic Plan for South African Agriculture*. It emphasises the need to enhance equitable access and participation in the livestock sector, improve global competitiveness and profitability, and ensure sustainable resource management (DoA, 2003). The major strategies to achieve these objectives, within an emerging farmer environment, will have to be multi-disciplinary and multi-sectoral, creating a holistic framework of intervention. These include:

- Training, mentorship and support programmes
- Recruitment of smallholder farmers to organised agricultural structures [a possible merger between producers' organisations like the Red Meat Producers' Organisation (RPO) (with a white membership) and the National Emerging Red Meat Producers' Organisation (NERPO) (a predominantly black organisation) serves as a case in point]
- Infrastructural and business premise training
- Formation of cooperative structures with shareholding by participants
- Promotion, participation and representation of black entrepreneurs in agribusiness, and
- Facilitate the utilisation of contract suppliers and downstream partners.

8.3.2 Livestock Policies in Eastern Africa: Kenya

In Kenya, the last livestock development policy was formulated in 1980 and emphasised increased production to make the country self-sufficient in livestock products. Since then, many livestock policy issues have been addressed in various other policy documents. One of the most important policy components was the first National Agricultural Research Programme (NARP I), which consolidated all livestock research activities of the Ministries of Agriculture and Livestock Development, under the Kenya Agricultural Research Institute (KARI) (KARI, 1989). This was followed by the second programme (NARP II) in 1993, which resulted in KARI adopting a farming systems approach in its research agenda (Abate, 2005). Since then there have been many changes, which include target group identification and integration in farming systems research and increased use of participatory and on-farm research approaches. The success of smallholder dairying in Kenya is largely as a result of the activities of the National Dairy Development Project started in 1980. In terms of research, NARP II emphasised adaptive research in the high potential areas where most smallholder dairy activities were located (Abate, 2005). It supported the formation of research-extension clusters and the involvement of farmers in research, in collaboration with International Agricultural Research Centres (IARCs) (Kilambya et al., 2004).

Based on the initial fundamental work of NARP I, other significant policy papers have been developed, including the *Dairy Development Policy Paper* of 1992, the *Food Policy Paper* of 1994 and different five-year development plans. The main thrust of these documents, within the national agricultural policy framework, is to establish a balance of policies that mixes public, private and beneficiary participation to build a self-sustaining system (Kajume and Muthee, 1998). Policy changes in the last decade have included price controls, privatisation and decentralisation. An important component of recent changes was to rationalise the Kenyan agricultural research system in order to contribute to sustainable research that is based on a farming systems perspective. Projects support the needs of the smallholder community in various agro-ecological zones, supported by national research programmes that have a strong regional orientation due to the existing differences in agro-ecological and production systems (KARI, 2005).

However, there is no specific livestock *research* strategy. Livestock research currently benefits from the relatively large number of IARCs in the country, with an emphasis on improvement of local breeds with exotic ones, and disease resistance. Of significance is the highly successful smallholder dairying programme in Kenya, based on indigenous genetic resources with a limited contribution from exotic germplasm, led by the International Livestock Research Institute (ILRI) (ILRI, 2004). Important advances have been made in this way towards improving the production and quality of the stock (Mulira, 1995).

Some issues emerge as priorities with respect to future development of livestock policies. The livestock sector is allocated only seven percent of the total agricultural budget, despite its importance. In addition, socio-economic research has been lacking in terms of credit and marketing infrastructure and profitability of enterprises (Kajume and Muthee, 1998). A focused, development-oriented livestock policy in Kenya could include the following issues:

- Increased productivity to meet the current demand
- Adequate funding for improved health services

- Promotion of the role of the private sector in livestock development
- Improving research-farmer-extension linkages, and
- Access to credit by smallholder farmers.

8.3.3 Similarities and Differences between Eastern and Southern Africa

The assessment of livestock production systems in Eastern and Southern Africa (with specific reference to Kenya and South Africa) has indicated a number of similarities and differences between the two sub-regions. Initially, some description of these issues are pertinent as it permits a sharper focus on the nature of the sub-regions, the roles and contribution of livestock, the types of production systems, priorities for research and the strategies required to address the opportunities presented for improvement of smallholder livestock production systems.

The major differences between the two sub-regions include:

- Incidence and levels of poverty (percentage of the population living below US$ 1 per day) are much greater in Kenya than in South Africa (50% and 24% respectively), which makes the challenge of poverty alleviation and food security more critical in Kenya (IFAD, 2001).
- The main agro-ecological zones in South Africa vary between arid and sub-humid, with the predominant area being sub-humid, while those in Kenya are predominantly arid with semi-arid and sub-humid areas (Winrock, 1992; Blench et al., 2003; Otte and Chilonda, 2003). In both cases, the majority of the population live in sub-humid areas.
- Increasing human and animal population densities, and greater pressures on available land in Kenya, make integrated natural resource management more complex than in South Africa. For instance, the population density in South Africa is approximately 36 persons per km^2, as opposed to approximately 54 persons per km^2 in Kenya (Bushan, 2002; StatsSA, 2003).
- A larger area in South Africa (85%) is mainly suited for livestock production than in Kenya (25%) (Bushan, 2002; DoA, 2003).

- Smallholder intensive dairy production is more advanced in Kenya (Nyambati, 1995; Waweru, 1998; Bebe et al., 2003).
- Landless urban and peri-urban production is more advanced in Kenya than in South Africa, largely because there are more non-agricultural employment opportunities in South Africa.
- Systems integrating tree crops and ruminants are much more common in Kenya than in South Africa (Place et al., 2003).
- The size and diversity of animal populations are much greater in Kenya. Furthermore, the number of indigenous breeds within species is larger in Kenya than in South Africa (Nyambati, 1995; Rege, 1998).
- Animal feed deficits are more critical in South Africa as a result of lower rainfall and temperature limitations (Kajume and Muthee, 1998; DoA, 2003).
- Feed resource availability varies as a major constraint to production in Kenya, while in South Africa it is consistently a main constraint (Kajume and Muthee, 1998).
- The integration of wildlife and livestock is far more advanced in Kenya than in South Africa (Boyd et al., 1999; Voeten, 1999).
- The marketing systems for smallholder farmers in Kenya and in South Africa are not conducive to trade, although it is better developed in Kenya than in South Africa (CTA, 1998; Bailey et al., 1999; Bebe et al., 2002).

The major similarities provide important linkages between the two sub-regions. These include:

- Both Kenya and South Africa are regarded as leaders in their respective sub-regions in terms of livestock production, smallholder development and regional agricultural research capacity.
- The lack of integration of farming system approaches and technology development and transfer in research is common to the two regions.

- Despite the interest in urban and peri-urban agriculture, this sector of the livestock industries, except for poultry, is relatively undeveloped in both countries.
- The integration of animals with annual cropping systems.
- Limited use of improved forages.
- Inadequate socio-economic and policy research and training focusing on livestock.
- The need to strengthen research capacity in the National Agricultural Research System (NARS).

8.3.4 Justification for Research

In future, the strategy for research to improve the contribution of livestock in integrated crop-livestock systems should target the rainfed areas. In these areas, sustainability of the food crop systems should be enhanced by the livestock in mixed farming systems. There are three justifications of this approach. Firstly, rainfed agriculture in Southern and Eastern Africa uses 80% and 48% of the total land area, respectively. Rainfed agriculture in South Africa and Kenya amounts to approximately 40% and 60% of the land area respectively (calculated from Winrock, 1992). Most of the farmers engaged in rainfed-agriculture are resource-poor smallholders, whose farms vary in size from 0.5 ha to 4.5 ha. The second reason is that increased demand for animal products, mainly from ruminants, but also progressively more from poultry, will be fuelled by rising populations, urbanisation and higher income, stimulating economic growth and competitiveness. For instance, the value of livestock systems in mixed rainfed arid and semi-arid tropical and subtropical Sub-Saharan Africa is estimated at US$3 billion (Winrock, 1992; FAOStat, 2002). Lastly, widespread poverty exists and concerns of equity and food insecurity are raised in these natural, extensive animal grazing areas. Especially in these areas, animals are the principal income generating factor to improve livelihoods. Arid and semi-arid areas particularly are vulnerable, and require conservation and protection. Due to overgrazing and shifting cultivation, erosion takes place, further depleting the land through nutrient loss.

8.3.5 Priority Research Areas

Research conducted in South Africa and Kenya has been extensively reviewed (Winrock, 1992; de Haan et al., 1997; Fitzhugh, 1998; ILRI, 1998; Delgado et al., 1999; FAO, 2000; DoA, 2003; ILRI, 2003). A considerable amount of disciplinary research has taken place in these regions, with some success. Progress has been made in many different fields, including genetic improvement of cattle through crossbreeding, environmentally adapted, nutritionally adequate grasses and legumes have been identified, and there have been notable developments in animal health through vaccine development for foot-and-mouth disease and other illnesses.

However, historically, a farming systems approach was lacking as much of the research was been conducted on research farms. In the same context, important interactions between crops and animals have been ignored. As a result, many technologies have been validated on farms but are seldom adopted.

In Sub-Saharan Africa, the lack of socio-economic information on the benefits of integrated crop-livestock systems is perhaps one of the most important priority research areas that are neglected. Reasons identified for this are:

- A lack of skilled social scientists with the NARS
- An inadequate understanding of the methodologies for crop-animal research
- Limited knowledge of the application of economic analysis in crop-animal systems
- Component technologies which are over-emphasised, and not integrated into the rest of the system
- The lack of concern for gender and other socio-economic and socio-cultural aspects of technology development and dissemination
- Poor linkages between farmers, researchers, extension workers and rural development planners
- A lack of village-level support mechanisms to sustain the adoption of new technologies.

Livestock policy research and analysis is essential to provide decision-makers with soundly formulated policy alternatives and to substantiate the important role of animal agriculture in the economy. Key priorities include the development of:

- Indigenous capacities for data collection to document the contribution of livestock to agriculture, employment creation and poverty alleviation
- Indigenous capacities to monitor vegetation changes using advanced methods
- A research programme that addresses the key policy changes needed in future to stimulate animal agriculture, such as fiscal, incentive and trade policies
- A research programme that strengthens institutional capacity to promote technology generation and transfer to increase the efficiency of animal agriculture
- A research programme that identifies appropriate policies for appropriate community-based natural resource management practises
- A research programme for the development of integrated, sustainable production systems.

These aspects are crucial for the development and empowerment of rural smallholder agriculture. The absence of appropriate research in these particular areas places limits on the capacity of smallholder agriculture to increase productivity and hence their income (IFPRI, 2001).

8.3.6 Guiding Principles for Research

Guiding principles for research to improve animal production in mixed farming systems in Sub-Saharan Africa, and specifically in South Africa and Kenya have been identified. These include:

- Research priorities within production systems, species and commodities need to be clearly defined

- Research should fuel sustainable development, by being problem-solving and application-driven
- Ex-ante analysis has to be included, as well as both production and post-production components based on these analyses (see chapter three, section 3.6). Participation in decision-making is central to the success of any project (Uphoff et al., 1998). Farmers and community organisations should be involved in order for the beneficiaries to have a direct stake in all aspects from its formulation to evaluation
- Institutional commitment to multi-disciplinary, farming systems-oriented and demand-led research is crucial
- Strong partnerships should be recognised and promoted by taking cognisance of the comparative advantage for research of public and private institutions. A symbiotic relationship should be developed between the NARS and these groups, led or facilitated by international research centres, to enhance impact
- In countries such as South Africa and Kenya, an integral issue would be the acknowledgement of concerns of poverty elimination, food security, environment, equity, gender and sustainability
- Research projects should also be flexible in scope and direction, and responsive to challenges.

A commitment to a farming systems approach will be more challenging and complex, but the circumstances dictate this focus. More importantly, the rewards for these integrated efforts should be more significant than in the past.

8.4 Towards Identifying Elements for a Livestock Policy Framework

Based on the previous analysis, the following elements and implications have been identified as core elements of an integrated policy framework for livestock development in Sub-Saharan Africa, more specifically in Southern and Eastern Africa. Elements of this integrated policy framework are spatially represented in Figure 8.1:

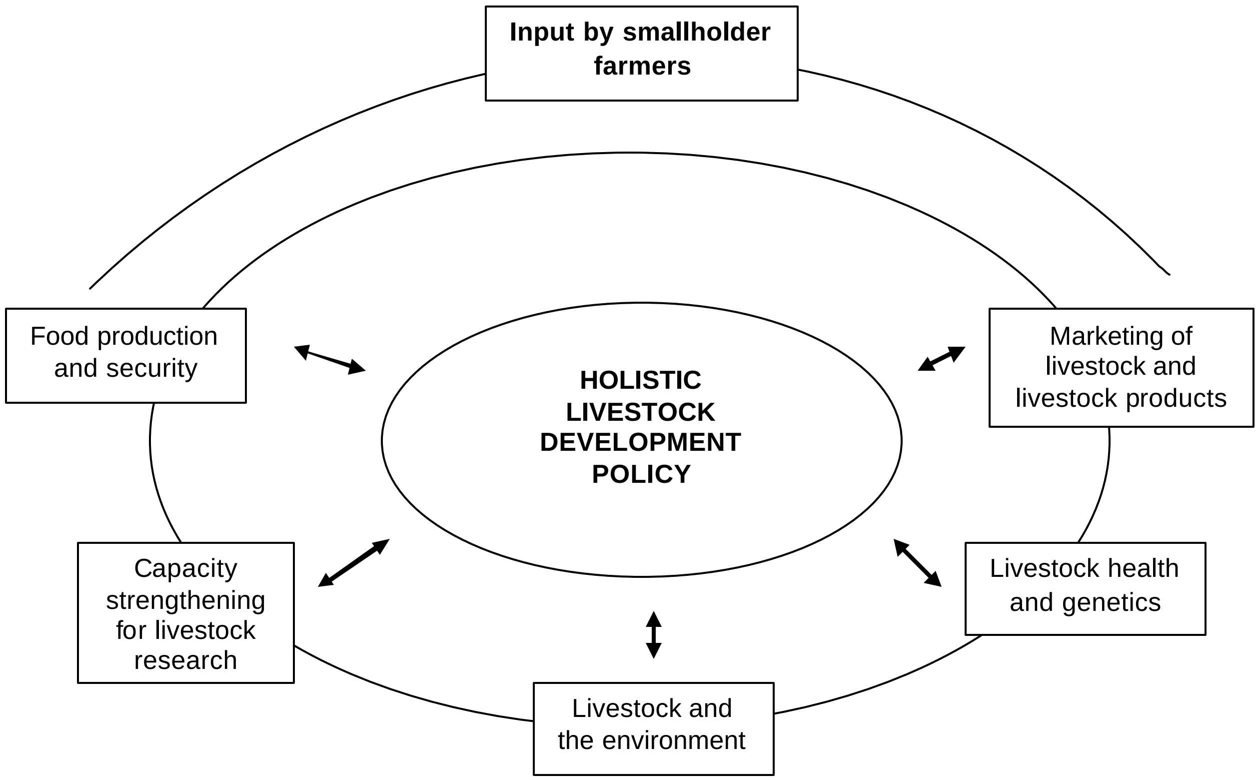

Figure 8.1 Spatial Integration of the Main Policy Issues affecting Livestock Production in Sub-Saharan Africa (adapted from Winrock, 1992; CTA, 1998; ILRI, 2000)

Food Production and Security

Within the regional contexts of South Africa and Kenya, it is critical to continuously monitor and analyse the supply and demand for livestock products. One critical aspect is the monitoring of animal food prices to establish whether projected decreases in animal food products actually occur, and its impact on human nutritional status. This in turn will determine whether the occurrence of research-based technologies that increases productivity (improved livestock production systems) provide better access of the poor to meat and dairy products. These technology and policy options are also needed to optimally balance income generation with nutritional security to facilitate decisions that will increase household diets. However, non-food uses of livestock, as a result of the decline in the relative importance of primary food production, will be of high importance within the framework of the value of livestock as an asset in building financial security, and the impact of finance and labour on women.

Capacity Strengthening for Livestock Research

Effective research partnerships involving diverse expertise are needed to deliver research products in a timely way. International agricultural research centres should assist national agricultural research systems in this regard through partnerships (i.e. with NARS) and capacity building initiatives. A concerted effort is needed to understand the reasons for poor technology adoption and ineffective delivery pathways. South-South partnerships and exchanges can contribute towards solving pervasive problems and constraints, especially when there are common problems.

Livestock and the Environment

The development of sustainable land use systems will be one of the major challenges facing animal agriculture and its influence on the environment. Such policy research should address: development of improved land use rights based on traditional or new systems, appropriate means of involving the producer organisations in the implementation of better adapted land use rights, incentives to increase offtake, i.e. introduction of grazing fees in communal areas; measures to mitigate the effect of drought and land tenure, management strategies leading to sustainable land use and effective tools to assist smallholder farmers to obtain greater value from wildlife, at the same time contributing to the maintenance of wild animal diversity.

Livestock Health and Genetics

Technologies and management to control disease need improvement to increase the productivity of smallholder intensive and extensive livestock farming systems. In the development of livestock systems that are sustainable and productive, the genetic capacity of livestock raised in an environment of endemic diseases should be identified. Taking cognisance of the developing context, practical and realistic techniques should be developed to maintain desired characteristics with required productivity traits through carefully planned crossbreeding. Improved feed and feeding technologies are required, with special reference to seasonal constraints.

Marketing of Livestock and Livestock Products

Marketing is probably one of the most complex policy issues to be addressed. There are a number of constraints to the efficient marketing of livestock and its products in Eastern and Southern Africa, including: poor marketing infrastructure, lack of marketing extension services, organisations and information and low purchasing power. The performance of existing marketing systems can be improved by alleviating some of these constraints and formulating and implementing policies, based on thorough research. Improved organisational arrangements, specifically addressing trade and marketing of smallholder systems, promote competition in input supply and provide a conducive framework for credit systems for smallholders, in partnership with the private sector. The utilisation of grading systems and standards for livestock and its products is increasingly important to meet consumer needs in producing quality meat. The most critical is the strengthening of awareness creation of marketing issues in the extension service.

8.5 Conclusion

The elements identified in this chapter summarise the priority areas for policy research, in order to compile a holistic, development-oriented framework for livestock development in Eastern and Southern Africa. It is based on findings from previous chapters (three - seven) on the socio-economic complexities of smallholder resource-poor ruminant livestock production systems, and has been integrated into existing issues and challenges identified by other researchers in previous research analysis as referred to elsewhere in this chapter. The framework that emerges from these findings is clearly one of urgency and at the same time of complexity. The urgency stems from the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production.

The complexity stems from livestock's use by smallholder agriculture for multiple needs, producing in the process multiple environmental benefits and costs. This framework emphasises that many of the policy challenges remain pertinent and important. Significant progress has been made to address some of these challenges, but the fact remains that the macro policy concerns that have been identified, need to be addressed. This translates into complex, multi-disciplinary and multi-sectoral policy implications for governments, and increasingly, for the private sector.

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CHAPTER 9

CONCLUSIONS

This study has illustrated that livestock systems continue to play an important role in the livelihood patterns of smallholder, ruminant livestock producers in Eastern and Southern Africa. These systems reflect varying constraints and different potentials for growth. The framework that emerges is complex and dynamic. The dramatically increasing demand for livestock products and the resulting far-reaching changes in the structure of smallholder livestock production affect how livestock are raised and marketed. Low animal productivity directly affects the financial status of the homestead. If the generally low reproduction and offtake percentages and high mortality figures in the South Africa study area were improved, fewer of these farmers would be vulnerable and poor. Various coping strategies of smallholder farmers to buffer against risk have been identified. These include effective integration of crop-livestock enterprises i.e. feeding of crop residues to livestock, and increasing the size of cattle and goat herds within environmental constraints.

The rationale for raising livestock is determined by human needs but these human needs must be integrated with environmental constraints to ensure efficient and sustainable use of the natural resource base. Livestock-environment interactions are typically second-level problems: livestock per se do not degrade the landscape but how they are managed dictates whether there will be adverse environmental impacts. Many examples have been cited where livestock have remained in equilibrium with natural resources and, even more importantly, are contributing to maintain ecosystem health, biodiversity, flexibility and societal cohesion. Livestock and the environment can achieve a balance while at the same time fulfilling humanity's food needs and contributing to sustainable economic growth. This study also highlighted that there are important situations where livestock are out of balance with the carrying capacity of the soil, water and air. Land degradation, deforestation, water pollution and greenhouse gas emission are the result, and in these areas urgent action is required.

This study used a farming systems approach to consider each farmer's unique situation. Understanding the role of the different components of the farming system, according to criteria used by farmers, contributed to the understanding of why farmers make particular decisions. Families have a range of complex objectives, all of which compete for the limited amount of available labour, land and cash. Effective management involves making tradeoffs among desired outcomes. New approaches to data collection, analysis and interpretation are needed to assess the impacts of new technologies, policies and institutional changes to ensure the development of smallholder and resource-poor farmers.

To promote the development of smallholder farmers, different policy options must be assessed and evaluated, bearing in mind the farmers' likely responses. New policies must include food production and security, capacity strengthening for livestock research, livestock and the environment, health and genetics and marketing of livestock and livestock products. An attempt has been made to translate these into complex, multi-disciplinary and multi-sectoral policy frameworks.

ANNEXURE 1

Abstract

Uittreksel

ABSTRACT

The challenge to overcome hunger remains one of the most serious confrontations facing humanity today. The threat of starvation is most serious in Africa, where an estimated 33% (138 million) of the population, mainly women and children, suffer from malnutrition. An estimated 680 million people, representing about two thirds of the rural poor, keep livestock, confirming the importance of livestock to their livelihoods. Understanding a livestock system requires description and analysis of its various components and their functional inter-relationships (the system's functioning), rather than the description of livestock production alone. Therefore, the purpose of this study was to analyse these relationships which are best understood by evaluating the various flows among system components as well as farmers' management decisions.

Farms vary in their resource endowments and in the family circumstances of the owners, with various resource flows and external interactions at the farm level. The biophysical, socio-economic and human elements of a farm are interdependent, and can be analysed as a system from various points of view. The challenges experienced in conducting diagnostic livestock studies are often attributed to the specific characteristics of livestock keeping. Taking cognisance of each farmer's unique environment and context is central to the framework of farming systems research.

No single component of smallholder farms in developing countries has as much potential as ruminant animals to address simultaneously the inter-related factors of under-nutrition, poverty and environmental decline that prevent people from improving their livelihoods. In mixed farming systems, as a result of the interplay among farm families, animals, crops and social systems, the roles and contributions of animals to smallholder agriculture are complex. The projected increased demand for livestock products could result in far-reaching changes in the structure of smallholder livestock production.

Livestock never interact with natural resources in isolation, but people as livestock managers play a deciding role and are affected by biophysical, economic, social and

policy factors. In this context, an integrated approach to natural resource management is required.

Eighty-six smallholder cattle farmers in the Nzhelele District of the Limpopo Province of South Africa were surveyed. The farmers owned between one and 67 cattle, with an average of 10.3 head of cattle per household. The average age at first calving was 34.3 months. The rates of calving, weaning, calf mortality, herd mortality and offtake were 49.4%, 34.2%, 26.1%, 15.6% and 7.8% respectively. Contrary to the situation in many other regions of Southern Africa, commercial enterprise, not social prestige, constituted the main reason for farming with cattle. A marked complimentarity in resource-use i.e. crop residues as animal forage, has been demonstrated. Family size is the single most important factor among all variables studied (farm size, grazing land area, cultivated area and maize production area) that influences herd size for cattle and goats. The most important factor limiting the amount of land cultivated and the area used for maize production is farm size. Farm size has no relationship to the number of cattle or goats owned, as livestock predominantly depend on communal grazing. Animal traction supported by family labour, played a prominent role in land cultivation, due to the small farm size.

Empirical studies and reviews from Eastern (Kenya) and Southern (South Africa) Africa has been used to construct a policy framework to guide livestock development in these two regions. Five overarching, integrated elements have been identified. These include food production and security, capacity strengthening for livestock research, livestock and the environment, health and genetics and marketing of livestock and livestock products. The framework that emerges is complex, due to the dramatically increasing demand for livestock products and, as a result, the far-reaching changes in the structure of smallholder livestock production.

To promote the development of smallholder farmers, different policy options must be assessed and evaluated, bearing in mind the farmers' likely responses. New policies must include food production and security, capacity strengthening for livestock research, livestock and the environment, health and genetics and marketing of livestock and livestock products. An attempt has been made to translate these into complex, multi-disciplinary and multi-sectoral policy frameworks.

UITTREKSEL

Die knelpunt om hongersnood te oorkom bly een van die grootste uitdagings. Ondervoeding is dramaties ernstig in Afrika, waar ‘n geraamde 33% of 138 miljoen mense, meestal vroue en kinders, aan wanvoeding lei. ‘n Beraamde 680 miljoen mense, wat twee-derdes van die wêreld se arm mense in ontwikkelende lande verteenwoordig, hou vee aan, wat die belangrikheid van vee in hul bestaan en lewens bevestig. Ten einde werklik ‘n veeproduksiestelsel te verstaan, is ‘n beskrywing en analise van die verskillende komponente, asook die interaksie tussen die komponente, noodsaaklik, en nie slegs ‘n beskrywing van produksie alleen nie. Die doel van die studie was om die komponente, asook die interaksie tussen die komponente, van kleinskaalse veeproduksiestelsels, asook die boere se bestuursbesluite, te analiseer.

Plase variëer ten opsigte van die beskikbaarheid van natuurlike hulpbronne, asook familie omstandighede, met gevolglike hulpbronvloei en eksterne interaksie. Die biofisiese, sosio-ekonomiese en menslike elemente van ‘n plaas is interafhanklik van mekaar en kan as ‘n stelsel vanuit verskeie hoekpunte ontleed word. Die uitdagings ten opsigte van die diagnostiese fase van veeproduksiestudies kan hoofsaaklik toegeskryf word aan die eienskappe waaronder vee aangehou word. Elke boer se unieke omgewing en konteks behoort in ag geneem te word in die raamwerk van navorsing van boerderystelsels.

Geen ander aspek van kleinskaalse boerderystelsels in ontwikkelende lande het soveel meriete as diè van ruminante (beeste, skape en bokke) nie, om gelyktydig die uitdaging van ondervoeding, armoede en omgewingsagteruitgang te verbeter en gevolglik positief by te dra tot verbetering van lewenskwaliteit van arm mense. Die rol en bydrae van diere in boerderystelsels is uiters kompleks as gevolg van die interaksie tussen mense, diere, plante en sosiale stelsels. Die voorgestelde toename in die verbruik van diereprodukte (vleis en melk) kan verreikende gevolge hê vir die struktuur en bedryf van kleinskaalse veeproduksiestelsels.

Die interaksie tussen plaasdiere en die omgewing is nooit in isolasie nie, aangesien die mens ‘n beduidende rol speel in die invloed met betrekking tot biofisiese, ekonomiese,

sosiale en beleidsfaktore. In hierdie konteks is ‘n geïntegreerde benadering tot volhoubare natuurlike hulpbronbestuur belangrik.

Onderhoude is met 86 kleinskaalse beesboere in die Nzhelele Distrik in die Limpopo Provinsie in Suid Afrika vir doeleindes van hierdie studie gevoer. Die boere het tussen een en 67 beeste gehad, met ‘n gemiddeld van 10.3 beeste per huishouding. Die ouderdom met eerste kalwing was 34.3 maande. Die kalf- en speenpersentasie, kalf- en kuddemortaliteit en verbruik en verkope (offtake), was 49.4%, 34.2%, 26.1%, 15.6% en 7.8% respektiewelik. Die hoofrede om met beeste te boer was vir kommersiële en nie vir sosiale doeleindes nie, soos in baie ander studies gerapporteer. Daar is ‘n duidelike aanwending van plaashulpbronne gerapporteer, bv. oesreste as veevoer. Gesinsgrootte was die enkel belangrikste faktor van al die veranderlikes (plaasgrootte, weidingsoppervlakte, bewerkbare grondoppervlakte en mielieproduksie area) wat ‘n invloed op die aantal beeste en bokke gehad het. Die belangrikste faktor wat ‘n beperking op die oppervlakte wat bewerk word en waarop mielies geplant word, gehad het, was die plaasgrootte. Die plaasgrootte het geen invloed op die aantal beeste en bokke wat aangehou word nie, aangesien beeste en bokke hoofsaaklik kommunaal wei. Trekdiere, ondersteun deur familie-arbeid, het ‘n prominente rol gespeel in grondbewerking as gevolg van die klein plaasgroottes.

Empiriese navorsing van Oos- (Kenia) en Suidelike Afrika (Suid Afrika) is gebruik om ‘n beleidsraamwerk vir die bevordering van veeproduksie in hierdie twee streke saam te stel. Vyf oorhoofse, geïntegreerde elemente, naamlik voedselproduksie- en sekuriteit, kapasiteitsontwikkeling vir navorsing, die omgewing, dieregesondheid en genetika asook bemarking van vee en veeprodukte is as van deurslaggewende belang geïdentifiseer. Die raamwerk is kompleks, hoofsaaklik as gevolg van die dramatiese toename wat in die verbruik van diereprodukte voorspel word. Dit mag wesentlike veranderinge vir die toekomstige struktuur van kleinskaalse veeboerdery inhou.

Vir die bevordering en ontwikkeling van kleinskaalse boerderystelsels, moet verskillende beleidsopsies oorweeg word, met inagneming van die moontlike reaksie van die boere. Nuwe beleidsrigtings behoort die vyf elemente wat voorheen geïdentifiseer is, in te sluit. ‘n Poging is aangewend om te skakel in ‘n komplekse, multidissiplinêre en mulitsektorale beleidsraamwerk.

ANNEXURE 2

Questionnaire

QUESTIONNAIRE

AN EVALUATION OF THE PRODUCTION CONSTRAINTS, LIVELIHOOD STRATEGIES AND MEASURES OF SUSTAINABILITY OF SMALLHOLDER RUMINANT LIVESTOCK PRODUCTION SYSTEMS BASED ON TWO CASE STUDIES FROM SOUTH AFRICA AND KENYA

Name of Farmer: ……………………………………………………………………..………...

Name of the Farm: ……………………………………………………………….………...

Name of the Settlement: ……………………………………………………………….

Telephone No: ……………………….…….

Enumerator………………………………….. Tel. No……………………………….……

SECTION A

1. Farmer Household Characteristics

1.1 Number of people in household ☐

1.2 Gender of people in the household. No. of males ☐ No. of females ☐

1.3 Age of people in the farmer's household.

Male

Age	1	2	3	4	5	6	7	8	9	10	11
>10											
11-18											
19-30											
31-40											
41-50											
51-60											
60+											

Female

Age	1	2	3	4	5	6	7	8	9	10	11
>10											
11-18											
19-30											
31-40											
41-50											
51-60											
60+											

1.4 The household is headed by:

Father ☐ Mother ☐ Other ☐

If other, specify the relation ☐

1.5 Marital status of head of the household

Single ☐ Married ☐ Divorced ☐ Widow ☐ Widower ☐

1.6 What is the level of highest education of household members?

	Children					Farmer	Spouse
None							
Grd1-Std 2							
Std 3-Std 6							
Std 6-Std 9							
Std 10							
Tertiary							

1.7 The farmer can speak, read and write the following languages?

	Speak	Read	Write
English			
Sotho			
Afrikaans			
Others(specify)			

2. Knowledge - Farming Experience

2.1 How long have you been farming? Years

2.2 Are you a full time (FT) or partial time farmer (PT)? FT PT

2.3 How long have you been farming on your current farm? Years

2.4 How long have you been farming with the current enterprises? Years

2.5 What other type of work do you and/or other members of your household do?

	Self employed	Farm worker	Industry worker	Office worker	Service worker	Professional	Farming only
Farmer							
Spouse							
Child 1							
Child 2							
Child 3							
Child 4							
Child 5							
Child 6							
Other (specify)							

2.6 What is your total household income (R's) per month?

0– 499	500–999	1000–1999	1500–1999	2000–2999	3000–4999	5000 +

2.7 What is your income from your farming activity per month?

0– 499	500–999	1000–1999	1500–1999	2000–2999	3000–4999	5000 +

2.8 As a farmer, indicate your arithmetic ability

	Adding	Subtracting	Multiplying	Dividing
None				
Little				
Average				
Good				

SECTION B

3. Farm Information

3.1 Who owns the land? a) Own ☐ b) Lease ☐ c) Tribal ☐

d) Communal ☐

3.2 What is the size of your farm (ha)? a) less than 5ha ☐ b) 5-10ha ☐

c) 10-15ha ☐ d) 15-20ha ☐ e) over 20ha ☐

3.3 Is the farm fenced? Yes ☐ No ☐

3.4 What herd structure do you operate with?

Cows (any female that has calved before)

Age (years)	Number
2-3	
3-4	
4-6	
7-9	
More than 9 years	

Heifers (young females which have not calved before)

Age (years)	Number
0-1	
1-2	
2-3	

Bulls

Age (years)	Number
0-1	
1-3	
3-5	
5-7	
Above 7 years	

Steers

Age (years)	Number
0-1	
1-3	
3-5	
5-7	
Above 7 years	

3.5 What cattle breed(s) do you use and why? (tick breed and reason applicable)

Cattle breed

Crossbreed (give name)	
Bonsmara	
Hereford	
Brahman	
Nguni	
Afrikaner	
Any breed	
Other (specify)	

3.6 Reason for choosing this breed

It was recommended to me	
Because of its size or colour	
Because most other farmers have this breed in the area	
Because it is adapted to my area	
Because it produces more milk	
Because it was the cheapest I could get	
I don't know why I am using this breed	
Other (state)	

3.7 Do you raise other species of animals? If yes, what type of animal(s)

Animal type	**Number of Males**	**Number of Females**
Sheep		
Goats		
Chicken		
Other (specify)		

3.7.1

Reasons for Farming	
Commercial purposes for money	
For lobola (bride prize)	
Bank on hoofs (Savings)	
Pay school & hospital fees	
For social prestige	
Others(specify)	

3.8 Do you raise crops? Yes ☐ No ☐

3.9 If yes to (3.8) above, what type of crops do you grow and to what extent (size)?

Type of crop	**Size in hectares**
Maize	
Sorghum	

Millet	
Vegetables	
Fruit	
Other (specify)	

3.10 What do you do with your crop residue? a) Feed to animals ☐

b) Leave on field ☐ c) Burn the residues ☐

d) Sell to other farmers ☐ e) Other (specify) ☐

3.11 If you feed the residue to your stock, do you: a) Cut and carry to animals ☐
b) Send animals to graze on field ☐

c) or do you plant the whole crop for the animals ☐

3.12 What other supplements do you provide? a) salt licks ☐

b) Mineral licks ☐ c) Mealie concentrate ☐

d) Mixture of above ☐ e) other (specify) ☐

f) No supplements provided ☐

3.13 Under what conditions do you supplement? a) Winter ☐ b) Summer ☐

c) Year round ☐ d) During Pregnancy ☐

e) Only in bad year ☐

3.14 Do you employ any labour? Yes (state number) ☐ No ☐

3.15 If yes, is employment temporary (T) ☐ or permanent (P) ☐

3.16 How many of: Permanent labour ☐ Temporary labour ☐

3.17 How do you pay your workers? I pay with:

Money (R/month)	
Milk (litres/day)	
Grain (kg/month)	
Combination of all or some of above (specify)	
Other (specify)	

3.18 If you pay with money, how much do you pay in total per month to:

Permanent workers	R
Temporary workers	R
Casual workers, if any	R

SECTION C

4. Production and Management Information

Biological

4.1 Do you keep records on your animals? Yes ☐ No ☐

4.2 What kind of records do you keep?

Production records i.e. births, wt of calf etc.	
Financial records i.e. input purchases, income from sales	
Health records i.e. diseases, treatment	
Sales records	
Others (specify)	

4.3 How do you identify your animals? A)Ear tags ☐

b) Fire brand with numbers ☐

c) Fire brand tattoos ☐ d) Other (specify) ☐

4.4 At what age (months) do your heifers first calve? a) 24 mths ☐

b) 30 mths ☐ c) 36 mths ☐ d) 42 mths ☐ e) 48 mths ☐

f) More than 48 mths ☐

4.5 How many females calved last year…………..and how many had calving difficulties or problems?……………

4.5.1 What was/were the cause(s) of the difficult births? a) Large calf ☐

b) Leg out first ☐ c) Wrong presentation (breech) ☐

d) Sick dams ☐ e) Other (specify) ☐

4.6 At what interval do your females calve: a) Every year ☐

b) Every 18 mths ☐ c) Every 24 months ☐ d) Every 30 mths ☐

e) 36 mths or more ☐

4.7 Do you take the weight of the new born calf? Yes ☐ No ☐

4.8 Do you wean or is separation natural? a) I wean ☐

b) Separation is natural ☐

4.9 If you wean, for what reason do you wean? a) Time to wean ☐

b) Time to breed cow ☐ c) Need milk for sale ☐

e) Other (specify) ☐

4.10 When do you wean? a) Soon after birth b) 2-3 mths old ☐ c) 4-5 mths ☐

d) 6-8mths ☐ e) 8-10mths ☐ f) 10-12 mths ☐

4.11 How many calves did you wean or separate successfully last year? ☐

Natural Resource and Environmental Issues

4.11 What type of veld do your animals graze from?

a) Communal ☐ b) Trust land ☐ c) Private owner ☐

d) Renting ☐

4.12 Do your animals also graze planted pasture?

a) Only on veld ☐ b) Also on pasture ☐

4.13 What is the size of the grazing veld?.……ha, and planted pasture, if any …………ha.

4.14 In your view, what is the present state of the veld as compared to when you started grazing your animals?

a) Better ☐ b) Same ☐ c) Poorer ☐

4.14.1 When did you start grazing your animals? ☐

4.15 Do you know the carrying capacity of your veld? Yes ☐ No ☐
If yes, what is your stocking rate? ☐

4.16 On how many hectares do you need to graze one cow with a calf per year for optimum production? a) less than 2 ha ☐ b) 2-4 ha ☐

c) 4-6 ha ☐ d) 6-8ha ☐ e) 9 ha or more ☐

4.17 What measures do you take to ensure adequate feed supply during winter and periods of feed shortage? a) Store fodder ☐ b) Buy fodder ☐

c) Borrow from neighbor ☐ d) Sell some animals ☐

e) I do nothing ☐

4.18 Do your animals graze on the same veld all year long or you move them?

a) Graze same veld ☐ b) Move once ☐ c) Twice ☐

d) More than twice ☐

4.19 Based on what do you move them? a) Veld status ☐ b) Time to move ☐

c) Season ☐ d) No more feed ☐

4.20 Are there any signs of erosion? Yes ☐ No ☐

4.21 If yes, how severe is the erosion? a) Very bad ☐ b) Bad ☐

c) Moderate ☐ d) Mild ☐

4.22 What do you think is (are) the cause(s)? a) Too many animals ☐

b) Stormy rains ☐ c) Wind ☐ d) Fire ☐

e) Bad cropping practices ☐

4.23 Have you made any attempt to prevent/control the erosion?

Yes ☐ No ☐

If yes, what do you do? a) I don't know what to do ☐

b) I am planting trees ☐ c) I am moving my animals ☐

d) Erecting contour ☐ e) Other ☐

Production Risk Reduction

4.24 Do you have any form of insurance against theft, loss of income etc?

Yes ☐ No ☐

4.25 Do you undertake any external, internal, disease control or vaccination programmes?

Yes ☐ No ☐.

If yes, indicate type of remedy and number of times/year

External parasites e.g. Ticks

Conventional remedy type	Traditional remedy type	No. of times/ year

Internal parasites e.g. Worms

Conventional remedy type	Traditional/herbal	No. of times/ year

Vaccinations

Diseases vaccinated against	Name of vaccine used	No. of times vaccinated

General medication e.g. Wounds

Name of common diseases	Name of drug/antibiotic used	No. of times/yr

4.26 Are your animals sheltered at night and in winter? Yes ☐ No ☐

4.27 If yes, what type of shelter do you provide? a) Roofless kraal ☐

b) Roofed kraal ☐ c) Open yard with trees ☐

d) On the veld ☐

4.28 How often do you see an extension officer?

Once per year	
Twice per year	
Three times per year	
Four times per year	
Five times per year	
Six times per year or more	
I don't see an extension officer at all	

4.29 Do you go (travel) to the extension officer or he/she comes to visit you at the farm?

a) I go (travel) to him/her ☐ b) He/she comes to me ☐

4.30 Are veterinary services or surgeon used? Yes ☐ No ☐

If yes, indicate how many times.

Once per year	
Twice per year	
Three times per year	
Four times per year	
Five times per year	
Six times per year or more	
I don't see a Vet. officer at all	

4.31 Do you go (travel) to the vet officer /vet clinic or he/she comes to visit you at your farm?

a) I go (travel) to him/her ☐ b) He/she comes to me ☐

4.30 If veterinary services are not used, please indicate as many reasons as possible.

Veterinary services are too expensive	
Have no money to afford Vet. services	
Veterinary services are not easily available	
Have no transport to get sick animals to veterinary surgeon	
Veterinary services are not necessary	
Other	

4.31 What source(s) of information do you make use of in your day to day decisions on the farm?

	Management and production decisions i.e. time to breed, supplement, etc	Financial decisions i.e. buying inputs	Marketing decisions i.e. time to sell & where, what price, etc.	When you need training or advice
Extension Officers				
Co-farmers (neighbors)				
Radio and/or television				
Co-operative manager				
Extension publications (newsletters, periodicals etc				
Own records				
Other				

4.31.1 To what extent to you rely on advice and assistance from your neighbors?

4.31.2 To what extent to you rely on advice and assistance from the extension officer?

4.32 What type of bull do you use for cattle breeding?

Registered bred bull	
Own bred bull	
Communally owned bull	
Borrow from neighbors	
Any bull available	

Artificial insemination	
Other (specify)	

4.33 Do you make use of breeding season or do your male(s) run with the female stock?

a) Use breeding season ☐ b) Male (s) run with female all year ☐

4.34 If you use breeding season, when do you breed? a) Winter ☐

b) Summer ☐ c) Spring ☐ d) Autumn ☐

4.35 How many of the following animals died last year, and for what reason?

Animal group	Number of deaths	Reason for death (Choose answer from reasons given below)
Cows		
Bulls		
Heifers		
Young bulls		
Oxen		
Steers		

Reasons for death

Sickness
Hunger or starvation
Killed by cars (accident), thugs etc
Attacked by predators
Stolen
Other (specify)

Marketing Management

4.36 Are there output markets available within an accessible distance from your farm?

Yes ☐ No ☐

4.37 Through which marketing system(s) do you market your livestock?

	Cattle	Other livestock
Auction or public sale		
Private sale		
Middlemen		
Cooperative		
Butchery		
Open market in town		

Local livestock traders		
Other (specify)		

4.38 Indicate the products that you usually offer for sale. a) Live animals

b) Milk c) Meat d) Dung e) Other (specify)

4.39 For what reasons do you sell the product (s) indicated above?

a) Routine sale for cash

b) To pay school /hospital fees c) For funeral expenses
d) In bad agricultural years (i.e. drought) e) Other (specify)

4.40 If you milk your animals, a) do you leave calves with dams all day

b) Separate calves from dam during the day

c) Separate calves at night d) Separate calves soon after birth and bucket feed

4.41 How many cows did you milk last year? State number.

4.42 Did you milk your cows a) all year b) only in summer

c) in winter

4.43 If you sell milk or meat, how often do you sell? a) Daily b) Weekly

c) Monthly d) Occasionally

e) Only when I need money

4.44 How many times per year do you organise your sales?

a) All year round b) Two times a year

c) Three times a year d) When needed

Economic Viability

4.45 How much did you spend on your farm for the last year?

Item	Amount (R)
Purchase of animals	
Feed & supplements	
Veterinary services & drugs	
Labour (permanent & temporary)	
Machinery & equipment	
Transport & marketing	
Extension services	
Training	
Levies i.e. on communal grazing land etc.	
Loan repayments	
Ploughing	
Other (specify)	
Other (specify)	

4.46 How much did you get from the sale of the following last year?

Item	Amount (R)
Weaners	
Cows	
Bulls	
Oxen	
Steers	
Milk	
Meat	
Dung	
Other animals except cattle i.e. sheep, goats, chicken	
Crops	
Others (specify)	

4.47 Do you have any other income besides income from the farm activity?

Yes ☐ No ☐

4.48 If yes, from what sources?

State source(s) of extra income	Amount (R) per year
Pension fund	
Tuck shop	
Transport business	
Subsidies i.e. from Govt, NGOs, Coop, etc	
From other family members	
Others (specify)	

Social Acceptability

4.49 Are you satisfied with the welfare of your family? Yes ☐ No ☐

4.50 If no, give reason (s) why you not satisfied.

Reason

Too much debt	
Constant lack of money to maintain family	
Poor housing for my family	
Lack of money to expand farm	
Farm income not enough	
Other (specify)	

4.51 Do you borrow money for your farming activities? Yes ☐ No ☐

4.52 If 'yes', indicate source, amount borrowed, interest rate and monthly payment.

Source	Amount borrowed	Monthly payment	Interest rate
Cooperative			
Commercial Banks (name)			
Stokvels			
Credit unions			
Family & friends			
Land bank			
Agric. Credit board			
Supplier's credit			
Other (specify)			

4.53 How far is your farm or settlement from town and the following services

	Less than	**Between**	**Between**	**More**

Facility	1km	1 & 2 km	2 & 3 km	than 3 km
Telephones				
Schools				
Health facilities				
Recreational facilities				
Post Offices				
Main Roads				
Veterinary services				
Extension services				
Co-operatives				
Others (indicate)				

4.54 What problems do you have with your neighbours /community because of your cattle farming activities? a) They destroy other people's crops ☐

b) Destroy the water source ☐

c) Invade and graze other farmers land ☐

d) Bring diseases and flies ☐

e) Expected to pay more for water used by my animals ☐

f) No complains and getting on well with my neighbours ☐

4.55 Are you personally happy with the progress being made on your livestock business?

Yes ☐ No ☐

If 'yes' give reason(s).

I am making enough money out of it	
It has enhance my status in the community	
I have a new sense of security for my family	
Other (specify)	

If 'no' give reason(s).

I am not making enough money	
It has put me in debt	
I don't get any support from any source	
Have problems with neighbors as a result of my animals	
Other reasons (specify)	

4.56 Do you think you need technical help or any other assistance to do better than you are currently doing or you are convinced that you are on track to becoming a successful livestock farmer?

Yes, I need help ☐ No, I don't need help ☐

Type of help	**Reason why you need this help**
Training	
Technical advice	
Financial i.e. credit	
Marketing of products	
Other (specify)	

4.57 Give any comment or information that you think is necessary to know about your farm.

APPENDIX 3

GPS Coordinates

GPSNO	GPSSOUTH	GPSEAST
1	22.983320	30.148000
2	22.984540	30.148050
3	22.983060	30.150130
4	22.983440	30.150070
5	22.984630	30.151660
6	22.983310	30.155650
7	22.981010	30.143600
9	22.981410	30.140300
10	22.983820	30.143070
11	22.985150	30.139810
12	22.984810	30.140720
13	22.986250	30.138580
14	22.985200	30.143060
15	22.985180	30.143790
16	22.987510	30.144760
17	22.987700	30.144810
18	22.988780	30.143320
19	22.986860	30.142640
20	22.985860	30.133060
21	22.986460	30.131180
22	22.987330	30.131330
23	22.987710	30.132450
24	22.988520	30.127390
25	22.990280	30.119590
26	22.989650	30.119120
27	22.995030	30.213770
28	22.993420	30.212840
29	22.993000	30.212000
30	22.993550	30.210140
31	22.993950	30.209870
32	22.993650	30.209560
33	22.993430	30.208600
34	22.994480	30.281700
36	22.994420	30.203330
35	22.664430	30.206170
37	22.987750	30.201240
38	22.993050	30.205700
39	22.990660	30.205260
40	22.991460	30.210790
41	22.990670	30.209970
42	22.903600	30.208700
43	22.986690	30.207770
44	22.994000	30.211570
45	22.991560	30.211280
46	22.995090	30.208030
47	22.994260	30.205720
48	22.992370	30.206630
49	22.993520	30.206130
50	22.993300	30.206240
52	22.992100	30.203670
51	22.992360	30.204080
53	22.992420	30.202750
54	22.992660	30.202900

GPSNO	GPSSOUTH	GPSEAST
55	22.991750	30.203200
56	22.994880	30.202990
57	22.874130	30.057470
58	22.876910	30.060230
59	22.877350	30.060620
60	22.877920	30.060910
61	22.874840	30.059690
65	22.875910	30.056540
66	22.876730	30.056700
62	22.874980	30.059090
63	22.874810	30.059240
64	22.875360	30.057050
67	22.877170	30.056610
68	22.877470	30.056730
69	22.878170	30.059930
70	22.877880	30.059600
71	22.877120	30.059450
73	22.875270	30.060220
72	22.875510	30.059230
74	22.874380	30.060280
75	22.874840	30.060160
76	22.874900	30.060590
77	22.874840	30.059960
78	22.875200	30.061510
79	22.874980	30.062180
80	22.875010	30.061940
81	22.875290	30.062410
82	22.875410	30.062620
83	22.875140	30.061310
84	22.875940	30.063020
85	22.874980	30.062940
86	22.876440	30.063230
87	22.876330	30.061590
88	22.875960	30.062210
89	22.872150	30.062330
90	22.870690	30.056070
91	22.875250	30.063060
92	22.858030	30.063330
93	22.990120	30.197120
94	22.990450	30.198090
95	22.991870	30.197680
96	22.994740	30.197230
97	22.994080	30.196160
98	22.993320	30.196380
99	22.991500	30.194120
100	22.990260	30.193270
101	22.992850	30.196380
102	22.996040	30.202320
103	22.996590	30.262350
104	22.990920	30.193550
105	22.995140	30.204750
107	22.809020	29.951090
108	22.809140	29.951310

GPSNO	GPSSOUTH	GPSEAST
109	22.809380	29.952630
110	22.811070	29.952780
111	22.808310	29.954380
113	22.803030	29.953110
112	22.804530	29.952250
114	22.803060	29.953300
114	22.802490	29.952660
115	22.802620	29.955000
116	22.802440	29.953200
117	22.801830	29.952570
118	22.801720	29.952860
119	22.801500	29.952100
120	22.801070	29.952080
121	22.800750	29.953850
122	22.798720	29.954130
123	22.797790	29.955410
124	22.798900	29.951420
125	22.799760	29.953280
126	22.799690	29.953020
127	22.799910	29.951870
128	22.798690	29.953330
129	22.798740	29.954860
130	22.800630	29.956640
131	22.801210	29.955960
132	22.801590	29.955340
133	22.799850	29.953730
134	22.799730	29.950430
135	22.799530	29.949140
136	22.800430	29.947520
137	22.801800	29.951740
138	22.801200	29.953910
139	22.801210	29.955070
140	22.803110	29.953790
141	22.805060	29.953660
142	22.494480	30.032500
143	22.494460	30.020410
144	22.494260	30.029190
145	22.494280	30.031710
146	22.493830	30.031650
147	22.496140	30.031260
148	22.521850	30.065780

GPSNO	GPSSOUTH	GPSEAST
149	22.521840	30.071740
150	22.425650	30.106500
151	22.426580	30.110000
152	22.424650	30.108370
153	22.425900	30.110000
154	22.426170	30.108250
155	22.424860	30.107590
156	22.426140	30.107020
157	22.517080	30.083640
158	22.514380	30.073950
159	22.521330	30.067190
160	22.524520	30.078710
161	22.520340	30.063820
162	22.521580	30.069860
163	22.526320	30.092150
164	22.531140	30.094790
165	22.516150	30.044790
166	22.523440	30.071830
167	22.515110	30.043210
168	22.520820	30.069350
169	22.424380	30.106870
170	22.424260	30.107100
171	22.424790	30.108230
172	22.425360	30.108560
173	22.425930	30.108550
174	22.424460	30.107040
175	22.424570	30.107130
176	22.426530	30.109630
177	22.425520	30.109400
178	22.530370	30.087210
179	22.520980	30.064440
180	22.521640	30.069880
181	22.521910	30.065970
182	22.522060	30.066240
183	22.528030	30.083160
184	22.516980	30.083670
185	22.514010	30.043310
186	22.521180	30.068140
187	22.521630	30.069590
188	22.521000	30.066630
189	22.522170	30.066080