TRANSFER AND ADOPTION OF TECHNOLOGY: THE CASE OF SHEEP AND GOAT FARMERS IN QWAQWA

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SUMMARY

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It is evident from the literature studied that very little is known about the characteristics and farm level factors (predictors) contributing to or affecting the adoption of livestock veterinary technologies of small ruminant (sheep and goat) farmers in former homelands and rural areas of South Africa. This study contributes by identifying and evaluating critical factors (variables) that predict the transfer, adoption and utilisation of livestock veterinary technologies by small ruminant farmers in Qwaqwa, a former homeland of South Africa.

A wide selection of variables had to be tested in this study due to the absence of previous studies. Logit and multinomial logit models are used to select predictors of adoption of five different livestock veterinary technologies. Of the 34 possible predictors, 20 were selected in one or more of the seven different logit models.

The suspension of **veterinary surgeon services** provided by the government at sheering sheds and farmer days before 1994, contributed to an increase in the costs of services, inputs and information. Together with the deterioration of infrastructure and institutions, this caused a collapse of the livestock veterinary technology transfer process in Qwaqwa. Farmers who want to adopt this technology (potential adopters), cannot do so because it became too expensive (increased transaction costs). When the assumption of elastic supply of services or inputs, and increased transport costs due to the farm's location is violated (**traditional definition** of adoption – potential adopters grouped with non-adopters), potentially misleading conclusions can be made regarding the

significance of variables (predictors) which contribute to technology adoption. It is for this reason that an **adapted definition** of adoption (potential adopters grouped with adopters) should be used in future research.

The results of **medication technology** indicate that grouping of livestock medication is essential if research on the characteristics of farmers using these technologies have to be estimated. The fact that former homeland farmers react on what they see when it comes to usage of veterinary medication technologies, making it more likely for them to adopt therapeutic medication for treatment (external, internal remedies and antibiotics) rather than prophylactic medication for prevention (vaccines), is evident throughout this study. **Vaccine** technology showed the lowest adoption level of the four medication groups studied.

The high adoption rates of **external parasite remedies** (no non-adopters) and **internal parasite remedies** (two non-adopters) confirm this conclusion. However, there is a severe lack of basic knowledge amongst farmers on the correct application of these remedies as the majority (86%) of the farmers applied these remedies incorrectly. The most important predictors of the adoption of **antibiotics** is access to roads. This medication technology is urgently needed when an animal is sick and access to roads decreases the cost of obtaining the drug.

Small ruminant farmers in this study tend not to be full adopters of all the different livestock veterinary technologies simultaneously. The fact that only 20 per cent of the farmers were **adopters** of veterinary surgeon services as well as **full adopters** of external parasite remedies and **partial adopters** of internal parasite remedies, antibiotics and vaccines, confirms this conclusion.

The efficiency of the present extension services in Qwaqwa on veterinary livestock technologies is very poor. Extension visits did not emerge as a significant predictor of adoption of any of the livestock veterinary technologies. The reappointment of a state veterinary surgeon, the retraining of inexperienced extension officers, the improvement of infrastructure and the development of farmer-to-farmer extension programmes, using the sheering association chair persons and young, educated and progressive farmers, must receive the highest priority in agricultural policy-making. The implementation of an affordable minimum herd health prophylactic package can contribute to the correct adoption of medication technologies resulting in higher farming efficiency, better profits and contribute to the alleviation of poverty of former homelands and rural areas of South Africa.

OPSOMMING

OORDRAGING EN AANVAARDING VAN TEGNOLOGIE: DIE GEVAL VAN SKAAP- EN BOKBOERE IN QWAQWA
deur
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Uit die literatuur wat in hierdie studie bestudeer is, is dit duidelik dat baie min bekend is oor die karaktertrekke en plaasvlakfaktore (voorspellers) wat bydra of 'n effek het op die aanvaarding van lewendehawe- veterinêre tegnologieë deur kleinveeboere in die voormalige tuislande en plattelandse areas in Suid-Afrika. Hierdie studie lewer 'n bydrae tot die identifisering en evaluering van kritiese faktore (veranderlikes) wat die oordraging, aanvaarding en gebruik van lewendehawe- veterinêre tegnologieë by kleinveeboere in Qwaqwa, 'n voormalige tuisland van Suid-Afrika, voorspel.

'n Wye verskeidenheid veranderlikes moes in hierdie studie gebruik word as gevolg van die afwesigheid van vorige studies oor hierdie onderwerp. Logit- en multinomiale logit-modelle is gebruik om die voorspellers van aanvaarding van vyf verskillende groepe van lewendehawe-veterinêre tegnologieë te selekteer. Van die 34 moontlike voorspellers, is 20 in een of meer van die sewe verskillende logit-modelle geselekteer.

Die opskorting van **veeartsenykundige dienste** wat tot 1994 deur die regering by skeerskure en boeredae voorsien is, het daartoe bygedra dat die koste van hierdie dienste, insette en inligting gestyg het. Tesame hiermee het die verval in die infrastruktuur en instellings aanleiding gegee tot 'n totale verval in die oordragingsproses van lewendehawe- veterinêre tegnologieë in Qwaqwa. Dit het meegebring dat boere wat hierdie tegnologie graag sou wou aanvaar (potensiële aanvaarders) dit nie kan doen nie omdat dit onbekostigbaar geword het as gevolg van verhoogde transaksiekoste. Wanneer die aanname van 'n elastiese aanbod van dienste of insette, asook verhoogde vervoerkoste as gevolg van die ligging van die plaas, verbreek word (**tradisionele definisie** – potensiële

aanvaarders gegroepeer saam met nie-aanvaarders), kan potensieel misleidende gevolgtrekkings gemaak word ten opsigte van die betekenisvolheid van veranderlikes (voorspellers) wat 'n bydrae lewer tot tegnologie-aanvaarding. Dit is as gevolg van hierdie rede dat die **aangepaste definisie** van aanvaarding (potensiële aanvaarders gegroepeer saam met aanvaarders) in toekomstige navorsing gebruik behoort te word.

Die resultate oor die **medikasietegnologieë** dui aan dat die groepering van lewendehawe-medikasie noodsaaklik is wanneer navorsing gedoen word om die karaktertrekke van boere wat hierdie tegnologieë gebruik, te voorspel. Die feit dat voormalige tuislandboere reageer op wat hulle sien (waarneem) wanneer dit kom by die gebruik van veterinêre medikasietegnologieë, gee aanleiding daartoe dat hulle eerder terapeutiese medikasie vir behandeling (eksterne en interne doseermiddels en antibiotika) gebruik as profilaktiese medikasie vir voorkoming (entstowwe), het deurgaans in die studie voorgekom. **Entstoftegnologieë** het die laagste aanvaardingsvlak van die vier medikasiegroepe wat bestudeer is, gehad.

Die hoë aanvaardingskoerse van **eksterne parasietdoseermiddels** (geen nie-aanvaarders) en **interne parasietdoseermiddels** (twee nie-aanvaarders) bevestig hierdie gevolgtrekking. Daar is egter 'n nypende tekort aan basiese kennis onder die kleinveeboere ten opsigte van die korrekte aanwending van hierdie doseermiddels omdat die meerderheid (86%) van die boere dit nie korrek gebruik nie. Die belangrikste voorspeller van die aanvaarding van **antibiotika** is "toegang tot paaie". Antibiotika word dringend benodig wanneer lewendehawe reeds siek is en toegang tot paaie verlaag die koste om hierdie medikasie te verkry.

Kleinveeboere in hierdie studie neig om nie gelyktydig volledige aanvaarders van al die verskillende lewendehawe- veterinêre tegnologieë te wees nie. Die feit dat slegs 20 persent van die boere **aanvaarders** van veeartsenykundige dienste asook **volledige aanvaarders** van eksterne parasietdoseermiddels en **gedeeltelike aanvaarders** van interne parasietdoseermiddels, antibiotika en entstowwe is, bevestig hierdie gevolgtrekking.

Die effektiwiteit van die huidige voorligtingdienste van veterinêre tegnologieë in Qwaqwa is uiters laag. Besoeke deur voorligters aan boere is nêrens as 'n betekenisvolle voorspeller van aanvaarding by enige van die lewendehawe- veterinêre tegnologieë geïdentifiseer nie. Die heraanstelling van 'n staatsveearts, die heropleiding van onervare voorligtingsbeamptes, die verbetering van die infrastruktuur en die ontwikkeling van boer-tot-boer voorligtingsprogramme in Qwaqwa deur gebruik te maak van die skeerassosiasievoorsitters en jong, opgeleide en progressiewe boere, behoort die hoogste prioriteit van landboubeleidmakers te geniet. Die implementering van 'n bekostigbare minimum kuddegesondheidsprofilaktiese pakket kan bydra tot die korrekte aanvaarding van medikasietegnologieë wat op sy beurt aanleiding behoort te gee tot hoër boerdery-effektiwiteit, beter winste en ook 'n bydrae te lewer tot die opheffing van armoede in die voormalige tuislande en plattelandse gebiede van Suid-Afrika.

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Chapter 1

INTRODUCTION

"... the great invention of the nineteenth century was the invention of the method of invention"

Alfred North Whitehead (1925).

1.1 BACKGROUND

Technology transfer and development is not a new concept, it has been around since mankind discovered things that they did not know before (Finlayson, 1995). A farmer is a rational decision-maker who normally strives for a better standard of living and seeks ways of adopting new technologies to accomplish this goal. Issues surrounding the relationship between differences in spatial location of farming activities, land utilisation patterns, the costs of adopting new technologies, costs of obtaining inputs, output services (markets) and information on new technologies, date back to the early nineteenth century. Johann Heinrich von Thünen, a German landowner and economist, developed a model in 1826 distinguishing between farmers located in concentric circles closer and further away from service and information centres (market places). He concluded that as farmers are located further away from these centres, the total production costs increase, due to increased transaction costs to obtain inputs, services and information, and the realised income from agricultural products decreases (price obtained at the market minus transaction costs) (Barlowe, 1978).

The adoption of new agricultural technologies has attracted considerable attention from development economists because the majority of populations in less developed countries derive most of their livelihoods from agricultural production (Feder, Just & Zilberman, 1985). Larson and Frisvold (1996) came to the conclusion that traditional extensive cropping systems are not sustainable and contribute to a large extent to the present state of soil degradation and poverty of farmers in Sub-Saharan Africa where, according to the Food and Agricultural Organization (FAO, 1995), at present more than one-third of its human population is classified as chronically under-nourished. In cases where new technologies were not adopted, the *per capita* cereal production in Sub-Saharan Africa declined at an average annual rate of over one percent between 1961 and 1991 (Sanders, Shapiro & Ramaswamy, 1996).

According to the Food and Agricultural Organization of the United Nations (FAO, 1995) the average contribution of animal products to the world food supply, in terms of calories and protein, is increasing, but the livestock contribution to African diet is declining. However, livestock potential to increase food production, including crop production in Africa, is now being recognized as a pastoralist production, particularly small ruminant production that is the only source of food which an arid ecosystem can sustain (Qureshi, 1996). Animal agriculture in Africa is, therefore, of immeasurable strategic importance, notwithstanding the fact that it is still, to a large extent, an industry practised by traditional stockman at subsistence level. This immense potential is limited by the traditional land tenure systems and subsistence farming practices (traditional technologies) that unfortunately seldom assure, or generate, adequate returns which can promote the development of more commercially orientated livestock production systems (Hofmeyer, 1996). New agricultural technologies and practices which are accepted by farmers within their operation capacity and render positive incentives, can contribute considerably to the alleviation of poverty and its related problems in this part of the international economy (Qureshi, 1996, Pinstrup-Andersen & Pandya-Lorch, 1997).

If agricultural technologies developed for farmers in developing countries are not transferred in a correct (appropriate) manner and adopted accordingly, all the effort by the researchers who developed new technologies would have been in vain. This is probably

why transfer and adoption of new technologies is perhaps one of the most popular written-about and controversial topics in developing agriculture.

Due to climatic conditions, South Africa is regarded as an arid to semi-arid country (Table 1.1), and one which is predominantly suited for livestock farming. The livestock industry in South Africa, to a large extent, forms the backbone of the South African agricultural industry, contributing to more than 50 per cent of total farm income (Van Niekerk, 1996). This, as well as the fact that no research was previously done on livestock veterinary technology transfer and adoption by emerging black small-scale farmers in South Africa, were the main motivations for this study. This type of research is essential for adequate supportive governmental policy formulation to develop the agriculture and alleviate poverty in former homeland rural areas of the country.

Table 1.1: **BIOCLIMATOLOGY OF SOUTH AFRICA**

Climatic zone	Area (%)	Annual rainfall (mm)	Annual evaporation (mm)	Aridity index
Arid	50	<500	>2 500	<0,2
Semi-arid	40	500 – 750	2 500 – 1 500	0,2 – 0,5
Sub-humid	10	>750	<1 500	>0,5

Source: United Nations Educational, Scientific and Cultural Organisation (UNESCO) (1977).

The present political priority is to reduce the differences created in the past, by supporting and developing the emerging semi-commercially orientated black livestock farmers in South Africa. In order to attend to these objectives, a functional extension network must be in place to introduce specific livestock technology programmes and guarantee a quality information flow in order to diffuse and transfer new tested and adapted livestock technologies, including veterinary technologies. Identifying small ruminant farmer characteristics, their needs and main constraints as well as the factors contributing or impeding the adoption of these modern and more productive technologies, is essential in order to identify and introduce the right policies. This basic step of new policy formulation cannot be overemphasised, and if this basic knowledge is not available, misleading actions and policies will not generate the desired results. This may result in a waste of time and resources.

The implementation of adapted technologies and a well-structured technology diffusion system to attend to the needs of the farmers involved, are therefore necessary for the development of a sustainable agriculture in South Africa (Düvel, 1994b).

Diseases and parasites form one of the main constraints to sheep and goat production. The economic losses due to diseases and parasites are considerably high, especially in densely populated areas with poor nutritional grazing value, and where veterinary and diagnostic services are weak (Devendra & McLeroy, 1982). Animal disease control in developing countries has universally been the concern of government and public service (Wilson & Lebbie, 1996). The correct usage of medication technologies is an important factor for the success of any livestock farming activity, as disease and high mortality are major constraints on livestock production in Southern Africa (McKinnon, 1985). The lack of information on the transfer and adoption of livestock veterinary surgeon services and medication technologies in South Africa makes this study important for the farming community, as well as the policy-makers of this country involved in extension programmes concerning small ruminant production and transfer of livestock veterinary technologies.

Qwaqwa, a former Sotho-speaking homeland (Figure 1.1), was chosen as study area because, as in many other former homelands, five major livestock and three cash crop technology transfer (diffusion) programmes (subsidised by the government) were launched between 1980 and 1993. Qwaqwa was one of the former homelands where these programmes were very active up to 1994. The black farmers in the former homeland of Qwaqwa who farm mainly with sheep (mutton and woolled) and goats (Boer and Angora) (in this study referring to as small ruminant farmers), used to receive regular veterinary and extension visits and could buy veterinary medication at a subsidised price at the shearing sheds and farmer days. However, after the 1994 general elections, most of the programmes on livestock technology transfer were abandoned and the small ruminant farmers were left on their own. Casual observations reveal that some of the farmers in Qwaqwa still use livestock veterinary technologies, whilst others have stopped using them as they are no longer available at subsidised prices at the sheering sheds (Claassens, 1998; Naude, 1998; Olivier, 1998). The effect of the suspension of veterinary services and subsidised medication at the sheering sheds and farmer days have contributed to an increase on the costs of these technologies, particularly regarding the transaction costs involved in obtaining these services, inputs and information.

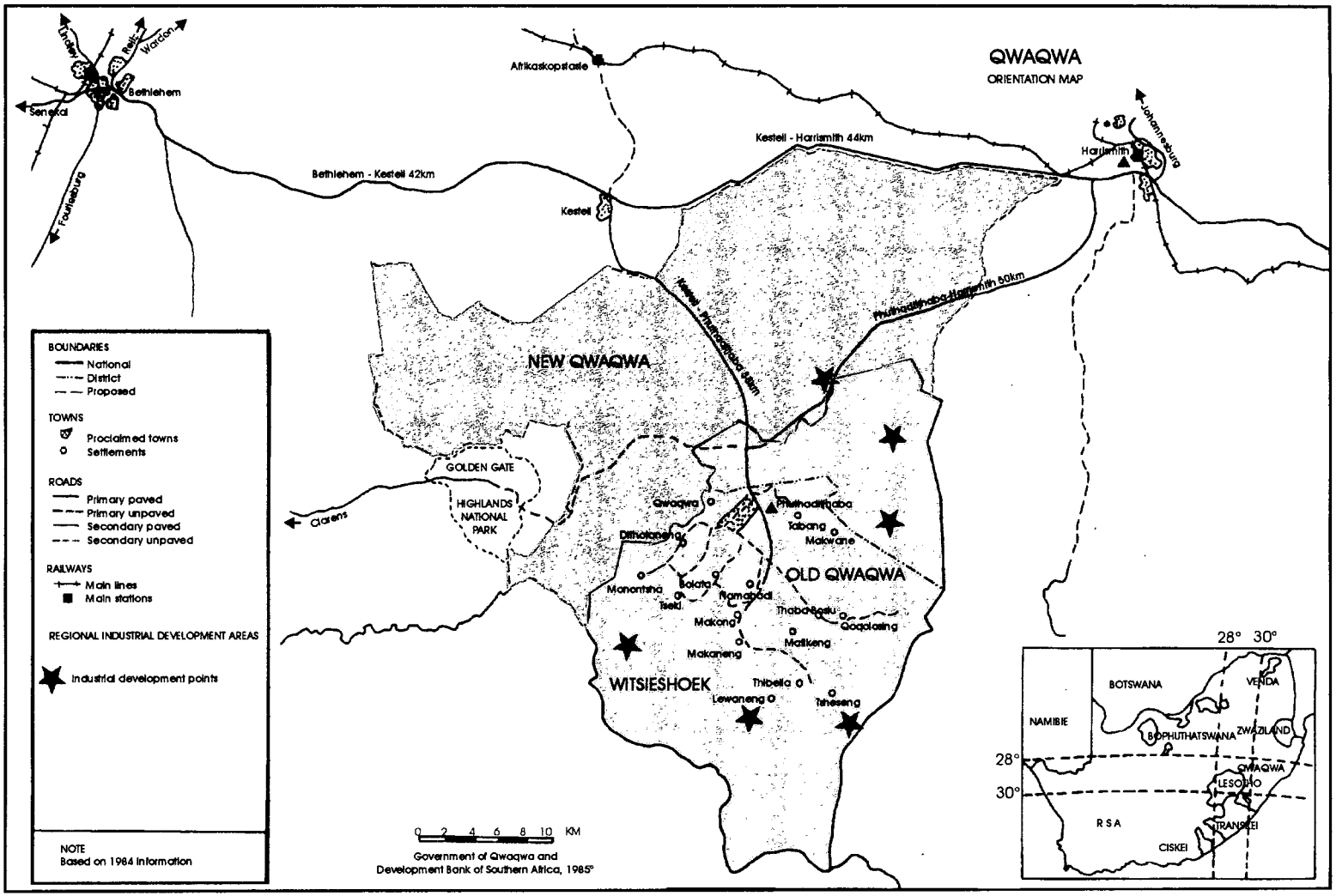

Figure 1.1: **Orientation map of Qwaqwa**

1.2 PROBLEM SETTING

In the former homelands of the Republic of South Africa, low productivity and high mortality rates among small ruminants (sheep and goats) are believed to be serious due to poor nutrition, diseases and parasites (Greyling, 1998). Very little is, however, known about the characteristics of small ruminant black farmers in these areas and farm-level factors (predictors) contributing to or affecting the adoption of new livestock veterinary technologies. It is extremely important to obtain this information for the formulation of appropriate and effective supporting agricultural policies. Well-formulated policies can improve the productivity of the more commercially orientated small ruminant farmers in former homelands and rural areas. The positive aspects could be strengthened and replicated in other areas of the country and the negative aspects minimised.

The Department of Agriculture has been the major vehicle of technology transfer to the former homeland farmers. With the country's political changes following the 1994 general elections and the restructuring of the extension services from the Department of Agriculture, there is a general perception that the present services are not efficiently transferring and supporting the adoption of technologies. It is important to evaluate the technology diffusion process and to identify factors to accelerate the process.

There is a need to identify the factors that contribute positively to the adoption of new livestock technologies, as well as those that represent main constraints for the diffusion/adoption process. This information is essential for policy-makers.

1.3 MAIN RESEARCH OBJECTIVE

The main research objective is to identify and evaluate the critical factors (variables) that predict the adoption of livestock veterinary technologies by small ruminant farmers in Qwaqwa.

1.3.1 Sub research objectives

- To determine the present adoption level of livestock veterinary technologies by small ruminant farmers in Qwaqwa.
- To identify the farm-level factors (predictors) affecting the decision to adopt small ruminant livestock veterinary technologies (veterinary surgeon services and medication technologies).
- To identify major constraints to accelerate the adoption of recommended livestock veterinary technologies by small ruminant farmers in Qwaqwa.
- To estimate the effects of the extension services and the present policies on the diffusion of small ruminant livestock veterinary technologies.
- To supply information to agricultural policy-makers to formulate more adequate agricultural policy guidelines on the diffusion of livestock veterinary technology transfer to small ruminant farmers in the former homelands and other rural agricultural development areas of South Africa.

1.4 OUTLINE OF THE STUDY

The underlying concern of the study is the identification of predictors contributing to the transfer and adoption of livestock veterinary technologies in Qwaqwa. In **Chapter 2** a literature review is done on agricultural technology transfer and adoption. The methodologies used by other researchers on technology transfer and adoption are identified and discussed. Variables (predictors) contributing to agricultural technology transfer and adoption in general, and when available more specifically on livestock technologies, are identified and discussed briefly.

The measurement of the dependent variables as well as the explanatory variables, hypothesised to affect the adoption of livestock veterinary technologies to be included in the applicable discrete choice models, are dealt with in **Chapter 3**. In the same chapter attention is also given to the survey, including the development of the questionnaire

(Annexure A). The chapter concludes with a short discussion of the methods followed to determine the possible predictors and the models (Annexure B) used to identify predictors contributing to adoption. In **Chapter 4** a description of the study area is given, as well as a background regarding the technology transfer programmes that were active in Qwaqwa until 1994. Factors influencing farming practices in Qwaqwa are also discussed in the same chapter.

In **Chapter 5** a description is given of the surveyed data that is used in the modelling of the adoption of livestock veterinary technologies.

The adoption of veterinary surgeon services technologies is analysed in **Chapter 6**. In this chapter a theory is developed to describe the so-called potential adopters of veterinary surgeon services where these services are not available and accessible to small ruminant farmers that would have adopted these services had it been available and accessible. This chapter also makes a distinction between the conventional definition of adopters (potential adopters classified as non-adopters) and the adapted/proposed definition of an adopter (potential adopters classified as adopters), for a less elastic/non elastic supply of technologies. **Chapter 7** deals with five models of medication technology adoption in the four more important distinct groups of livestock medication, namely external parasite remedies, internal parasite remedies, antibiotics and vaccines. In the final chapter (**Chapter 8**) a summary of results is given in terms of the explanatory variables included as predictors in the seven different logit models. The chapter concludes with general conclusions and recommendations for further research.

Chapter 2

LITERATURE REVIEW

"Change is inevitable in a progressive society.
Change is constant."

Benjamin Disraeli.

2.1 INTRODUCTION

One of the components (subsystems) of any development system is technological development or change. Whether positive or negative, change is inevitable in any part of the world and is part of the development of life. The transfer and adoption of newly developed technologies were and will always be part of the development system of mankind. Sunter (1996) said that the rules of the "game" are going to get very strict and that the person or institution that do not adapt to new technologies will experience increasing penalties for failure that will end up in bankruptcy.

It is well-documented that the "Western" agricultural model went through a technological explosion. With the liberalisation of national and international trade and markets, the farmers who do not adapt to these changes by adopting new the technologies of modern agriculture, would not be able to compete in the marketplace of this liberalised world (Nell, 1997). The agricultural development strategies followed by most governments in less developed countries who have interests in agricultural planning, vary to a large degree, but can be regrouped as the "Western" model of development. This is generally

equated with increased production and the need to increase the production level of small farmers (Gibbons, De Koninck & Hasan, 1980).

During the first three decades after the Second World War the gap in agricultural productivity widened sharply between developed and developing countries (Third World). Technological breakthroughs in this period concentrated mainly on grain technologies (Hayami & Ruttan, 1985) and high-potential areas with favourable climatic conditions (Otsuka & Delgado, 1995). During the same period the development of livestock technologies were neglected mainly because the returns obtained on crop technology were much more spectacular than those of livestock technologies (De Boer, Knipscheer & Kartamulia, 1992). Nevertheless, the development and adoption of livestock technologies remain important for livestock farmers. Vink (1986) stated that research on agricultural development in Sub-Saharan Africa has taken little note of the problems of the livestock sub-sector despite its importance in terms of the availability of resources.

Ten years ago Spies (1987) pointed out that agricultural development will be characterised by a transformation from an agrarian agriculture with a very high dependency on quality and quantity of natural resources, to a commercial agriculture which will be more dependent on new technologies, quality of farmers and the availability of capital. He also stated that the emphasis will fall on the development of black emerging commercial farmers and that the need for "effective technology transfer" in the South African agriculture will increase in future. Long-term growth in agricultural production will depend on the implementation of healthy long-term strategies which will stimulate entrepreneurship and technological innovation. Agriculture is not a machine but a vibrant pulsing socio-economic system, particularly in countries where a considerable part of the annual *per capita* income is generated from the agricultural sector, as is the case in South Africa.

Although some research has been done on livestock production in developing areas of South Africa (Afful, 1997; Anim, 1997; Fényes, 1982; Naledzani, Ortman & Lyne, 1989;

Nkosi & Kirsten, 1993 & Vink, 1986), very little attention was given to livestock technology transfer and adoption and even less to livestock veterinary technology transfer and adoption in the former rural homeland areas. Very little is known about the characteristics of black emerging small ruminant farmers adopting livestock veterinary technologies in South Africa. This is very strange for a country where most of its land is not suited for crop production and most of the agricultural land is therefore used for livestock production.

This chapter will attempt to provide an insight on how technology development functions as a subsystem within the total development system, as well as how the economies of countries and the lives of people all over the developing world are affected, especially on communities and its effect on the development of new technologies. The variables (predictors) contributing to the transfer, diffusion, adoption and usage of new technologies will be identified by the existing literature on agricultural technology transfer and adoption and discussed from the point of view of this study. This is done in three main sections. The **first section** discusses the role of agricultural technological change in developing countries, the **next section** deals with the methodologies and the mathematical models (discrete choice models) used by other researchers on the identification of farmer characteristics and predictors on technology transfer and adoption studies and **the last section** identifies predictors (variables) contributing to technology transfer, adoption, progress and usage reported in the literature.

2.2 THE ROLE OF AGRICULTURAL TECHNOLOGICAL CHANGE IN DEVELOPING COUNTRIES

Technological change can become a major vehicle in agricultural development reaching far beyond the more immediate goals of increasing production and satisfying food and nutritional needs as well as the alleviation of poverty (Birowo & Qasem, 1987a). Only by using a properly integrated multidisciplinary, holistic approach as an overall development strategy system can its full potential for achieving growth and equity goals

be achieved. New technologies must be planned and developed on a multidisciplinary partnership basis, with the participation of the end users (farmers) (Borlaug, 1988). Owens (1993) shares this view in stating that the development of new technologies must be planned and developed in participation with the end users (farmers), which will make the technology transfer process more impact-orientated and increase its adoption rate. Appropriate public policy and institutional changes (reforms) must accompany and support this strategy.

Leaver (1994) emphasises the importance of a holistic multidisciplinary approach of technology transfer in a sustainable agricultural development system. It is essential to identify problems and solutions with the participation of farmers on the adoption of the new technologies. Gibbon (1994) shares the viewpoint of Leaver in that he argues that agricultural research institutions remain dominated by the prevailing Western scientific paradigm. Farmers or potential users of technology, as well as all the disciplines involved in development of a specific technology, must become involved in research planning or decision-making. Low (1990) came to the same conclusion from his experience that all the elements necessary for technology transfer and adoption can be available, but if an integrated or multidisciplinary approach to research, extension and support services is not followed, the technology transfer and adoption process will not be sustainable.

According to Clark and Juma (1991) the history of contemporary development has shown that technological change is not deterministic and therefore its evolution can be governed in order to achieve certain social goals. Pehu (1994) goes further by stating that the scientific community, those setting research priorities and the target group where biotechnology is going to be applied, must have a say in the way biotechnology is going to be applied. Düvel (1994a, 1994b) goes even further and indicates that the adoption of new technologies is hardly possible if there is a perceived incompatibility between the innovation (technology) and the needs of an individual.

Experiences over the last 30 years have demonstrated the importance of institutional reforms related to the agricultural sector to implement new technologies (Norton &

Alwang, 1993). These reforms have been proven important not only to production incentives and to the distribution of economic gains, but also on the types of technologies produced and adopted. Land reform, improved credit policies, marketing system development, non-discriminatory pricing policies, and incentive systems to reduce environmental externalities are important institutional changes that are crucial for the success of the technology transfer and adoption system. Bembridge (1987) stated that "[n]ew technologies are not gifts of nature and institutional changes do not magically appear". Bembridge (1987) also recommended institutional reform and advancing technology by improving draught power, evaluating intercropping systems, integrating crop and livestock production, and developing technology for improving plant and weed control to narrow the "gap" between farmer yields and potential yields in Transkei.

2.2.1 The role of the technological subsystem in the developmental system

Development is a total system, open or closed, which consists of certain developmental actions (parts) that synergistically generates a higher energy than it would have, had the different parts been functioning on their own. If synergy exists between technology, tenure, infrastructure and financial institutions, the total developmental system will foster entrepreneurship and sustainable agricultural progress or development (Groenewald, 1993). The technological development subsystem is an integral part of the total developmental system. The Practice Model of Development that was developed by Wessels (1996) provides a significant, broader frame of mind from which practical developmental programmes could be adapted to suit different needs.

Three of the most important constraints to agricultural development in West Africa reported by Sanders, Shapiro and Ramaswamy (1996) are:

- "inadequate adoption and diffusion of the substantial achievements of public investment in agricultural technology research over the last 20 years;
- the failure of economic policies to encourage output and investment in the agricultural sector; and

- the inability of farmers to acquire capital either from their own savings or from the private or public sectors to finance the increased input purchases necessary for technological change in agriculture."

These constraints are interrelated. Higher inputs are required to increase yields. An economic environment in which profits can be made at an acceptable level of risk, the provision of adapted agricultural technologies, and the evolution of input and product marketing systems are necessary conditions to encourage farmers to purchase more inputs (McMillan *et al.*, 1997; Mahmud & Muqtada, 1988).

Development is all about growth and change in order to provide a better way of life. To achieve this in agricultural development, the spendable income of farmers must increase. Welch (1978) stated that "agricultural development is knowledge in use". Sanders, Southgate and Lee (1995) feel that developing countries need to increase their yields (crops) or reproduction levels (livestock) - total production per hectare - and that many productivity-increasing technologies are more sustainable than area-expansion technologies in developing countries. Water and soil retention techniques, irrigation, adequate management techniques, including breeding, feeding, veterinary and medication, are examples of adequate technologies needed in low-income (low rainfall) countries. Policy reviews such as the structural-adjustment programmes, to reduce price distortions and to strengthen property rights are essential to guarantee the success of new technology adoption which may result in a more productive and sustainable agricultural sector. Poor property rights and inefficient price signals discourage farmers throughout the developing world, from adopting land conservation measures or technologies that are essential for sustainable agricultural development. Stacy, Van Zyl and Kirsten (1994) share this view and stated that a "package of prime movers" is necessary to sustain agricultural development and increase the quality of life for those involved in the advantage of new technologies.

2.2.2 Policies and constraints regarding technology transfer and adoption

Raikes (1994) stressed the importance of agricultural policies that must be in place to assist with the transformation process of new technologies. Chopra (1986) examined the impact of the Green Revolution in four states of India, analysing the reasons for success in Punjab and Haryana and its failure in the western Uttar, Paradesh and Bihar regions. He came to the conclusion that in the case of the first two states, the administrative support in the form of policies to support the adoption of new technologies by the government has contributed directly to the successful development of technology and its transfer and adoption processes.

Blackie (1987) felt that a responsive and productive agricultural sector in Sub-Saharan Africa can be developed by using government policies to regulate rather than to manage the delivery of services essential to agricultural development and technological change. Central to this process is the effective participation of the small-scale farmer in determining agricultural policies. Sanders and Shapiro (1998) feel that it is the responsibility of governments to draft supportive policies to assist farmers to introduce new technologies if they are not in a position to adopt these technologies on their own. The policies of the public sector must be directed in such a way that infrastructure can be extended. The maintenance of agricultural research and investment in water research technologies will all help to reduce risk for emerging farmers (Sanders *et al.*, 1996). Clark and Juma (1991) argue that an understanding of the strategic dynamics of the major new technologies must form an integral part of the policy-making process. The development of biotechnology for the Third World must include a dimension of long-term environmental stability that must be incorporated into policy formulation and implementation.

According to Mijindadi (1995), four major elements are critical in the agricultural technology transfer process, namely:

- Identification of the problems and needs of potential end users - technologies must be relevant to identified needs.

- Testing and adaptation of new technologies to the local environment of the users - technical, social, environmental and economic issues must be addressed. This is essential for profitability (incentives) and sustainability;

- Existence of government or official regulations to provide decision mechanisms for approval and release of new technologies to users - technologies must be well proven and authenticated.

- Effective operation of a communication process - approved technologies must be passed on to users, through an extension services system.

Two other factors also aid the technology transfer process, namely:

- Provision of regular training on the use of innovations.
- Incorporation of technology related services in extension programmes.

The success of new technologies will be determined by its adoption rate (Sarch, 1993). The adoption of new technologies is an ongoing process in developing agriculture. It was found that after the initial adoption of new agricultural technologies during the Green Revolution in Asia, farmers increased their expected income dramatically until 1980. Thereafter there was a stagnation in the income levels of rice farmers due to a decline in the real price of rice and a decline on rice research for the development of new improved cultivars (Jatileksono & Otsuka, 1993; Otsuka, Gascon, & Asano, 1994; Otsuka & Delgado, 1995).

Stacy *et al.* (1994) found that the adoption of new technologies increases the productivity of land and labour. However, adoption behaviour differs across socio-economic groups and over time. Wealth derived from the adoption of new technologies enables further adoption that affects the dynamic pattern of aggregate adoption. Differential rates of technology adoption by different socio-economic groups disappear once the process is sufficiently advanced.

According to Birowo, Gondowarsito and Harrison (1989) the following factors were basic constraints to rapid adoption of new technologies or innovations:

- Inappropriate transport infrastructure.
- Limited access to information.
- Insufficient human capital.
- Aversion to risk.
- Lack of credit.
- Social acceptability of introduced, albeit imposed, change.

The explosion of both technology innovations and development and means of communication, as well as the provision of information, made the transfer process highly sophisticated and is increasing at an almost exponential rate in developed countries. The usefulness (value) of new technologies (innovations) and their marginal cost (cost of the technology and transaction cost), in relation to the needs and wants to be satisfied, determines their rate and extent of adoption by the farmers. A discrete science has evolved in studying the process of agricultural technology transfer and means to improve its rate of adoption by farmers (Finlayson, 1995). Besides the actual cost of a certain technology, other costs are involved in obtaining it - transaction costs, which, for instance, are related to transport costs. These costs will vary depending on the location of the farm, transport infrastructure and access to information and suppliers of inputs. It is therefore important to keep transaction costs in mind when studies are done on technology transfer and adoption.

2.2.2.1 Transaction costs and Von Thünen's theory

According to Vink (1986) transaction costs can be divided into three stages (sections), namely *ex anté*, actual and *ex post* transaction costs. ***Ex anté* costs** are the costs involved in obtaining an input which include, for instance, transport to and from the supplier of medication or to the markets. **Actual costs** are those costs incurred during the transaction itself, such as commission at the livestock auction kraals, value-added tax payable with the

purchase of the medication, etc. ***Ex post* costs** are those costs for the second party who, for instance, have to transport the animals from the auction to the farm. There are always two parties involved and the costs are never equally shared between the parties. According to Vink (1998) the farmers always come off second best, as they are the party who are always on the weaker negotiating side of the transaction.

Pearce and Turner (1990) elaborate on the bargaining side of transaction costs by stating: "Such costs include those of bringing the parties together, organising often widely distributed and difficult-to-identify sufferers, the actual bargain itself and so on. If the transactions costs are so large that any *one* party's share of them outweighs the expected benefits [incentives] of the bargain, that party will withdraw from the bargain, or not even commence it. Moreover, it seems likely that transactions costs will fall on the party that does not have the property rights. But transactions costs are real costs - we have no reason for treating them differently to other costs in the economy. Thus, if transactions costs are very high all we appear to be saying is that the costs of the bargain outweigh any benefits. In that case it is *optimal* that no bargain occurs." This resembles the situation found in Qwaqwa where farmers sometimes have to travel long distances to obtain technological inputs, services or information on livestock veterinary technologies.

One of the first analysis on the relationship between the differences in spatial location was developed by J. H. von Thünen in his book *Der Isolierte Staat*, written in 1826 (Barlowe, 1978). This theory clearly illustrates the negative effect of increased transport costs (*ex anté*) with respect to adoption of inputs, services, information and use of markets. As farmers are allocated further away from the supplier centres, the cost to obtain new technologies increases, decreasing the possible incentives and the adoption of these technologies. Many countries where new agricultural technologies are promoted, tried to achieve maximum adoption of these technologies by removing some of the actual costs of new technologies (direct subsidies) and others by introducing extension services (to reduce the transaction costs of information).

2.2.3 Livestock technology transfer and adoption

McMillan *et al.* (1997) found that when new disease-free areas are opened to mixed and livestock farming and new livestock technologies have not been transferred and adopted, after a decade the income decreases to about half of the initial income and more efficient farmers will migrate to other frontier areas where technologies and infrastructure are available. Improvement in livestock technology is more complicated than in crop production. The usage of gradual improvements, which include "best-farmer" practices and other on-farm technology improvements result in a slow production growth. Sanders and Shapiro (1998) referred to Ruttan (1991) who pointed out that the diffusion of "best-farmer practices" leads to very slow rates of production growth, namely one to two per cent, whereas science-based changes can increase production growth up to three or four per cent. They further suggest that new technologies should be developed in order to promote better integrated crop-livestock systems and more intensive livestock systems to obtain rapid growth rates and to respond to the increasing demand for animal food products for the needs of the growing population.

The shift to more intensive technologies also implies an improved management of natural resources (land, water and natural veld or grazing) compared to extensive strategies (low-input systems) (Sanders *et al.*, 1996). The introduction of livestock production systems, intensive in the higher rainfall areas and extensive in the lower rainfall areas, in combination with improved technologies can contribute much to sustainable agricultural development in Sub-Saharan Africa.

De Boer *et al.* (1992) listed the following factors (constraints) which limited technology transfer for livestock in Indonesia:

- Their longer production cycle (18 to 24 months with cattle).
- Lack of clear and observable animal responses to treatment.
- Inability of the research extension and banking systems to work closely together to develop a profitable "package".

- The smaller role of livestock in generating family income.
- Employment and consumption relative to crops.
- The multiple role animals play in the complex farming systems of Indonesia.

The diffusion of innovations or technologies should be left to more efficient channels of communication, which will increase the adoption rate. Bembridge and Schimming (1991) also made similar recommendations concerning the technology transfer process to increase the adoption rate of new technologies for Karakoel farmers in the Rehoboth district of Namibia.

The approach "Seeking Innovations" in livestock farming, where the poor small farmers adopt new improved innovations (technologies) from the wealthier larger farmers, had great positive results. This approach can be described as a successful way in transferring new technologies to farmers who need it the most (Holden, 1992).

2.2.3.1 Transfer and adoption of livestock veterinary technologies

Nagy, Sanders and Ohm (1988), in their on-farm trails and in whole-farm modelling results, found that all the applicable or available technologies would need to be adopted together as a package before economic incentives and risk levels will be adequately adopted by the farmer. They stated that the principal reason for the failure to adopt new technologies as a package, is the complexity of the large initial financial, human capital, managerial and labour requirements. Researchers must develop new technologies that, at an early stage, will provide sufficient economic incentives at low risk, with lower financial, human capital, managerial and labour requirements that will be more attractive to farmers. Supportive programmes in the initial stages of technology transfer and adoption are essential if the farmers do not have the necessary resources for technology adoption. These support programmes must include the following:

- Credit programmes to help the farmers with business capital.
- Farm management information, especially on the efficient utilisation of the new technologies to be adopted.
- Development of input and product markets (Nagy, Sanders & Ohm., 1986).

Empirical evidence indicated that farmers do adopt new technologies not as packages but sequentially en route to the adoption of the total package (Byerlee & Hesse de Polanco, 1986). If a total health programme is not adopted by the small ruminant farmer he/she may experience reproduction and growth problems or even high mortality rates. These farmers must also be assisted with the necessary support programmes as indicated (Swanepoel & Hoogenboezem, 1995).

Bhattacharyya *et al.* (1997) studied the rate of adoption of Trichomoniasis vaccine amongst range cattle farmers in Nevada, which is one of the few studies on the adoption of medication technologies that could be found. Their results showed that the use of computers (for information flow), consulting of veterinary surgeons and herd size were the most important predictors for the adoption of this vaccine. They also found that cooperative extension programmes enhance the rate of adoption.

2.2.4 Technology transfer and adoption in South Africa

The aridity index (see Table 1.1) of South Africa indicates that 90 per cent of the country is arid and semi-arid, which is perhaps one of the main reasons why agricultural development went through difficult stages in the past. South Africa has furthermore the unique situation in Africa concerning agricultural development, because approximately 95 per cent of the agricultural production is produced by highly technical developed commercial farmers who operate in a free market with nearly zero subsidies. In the South African agricultural system, farmers can be grouped into three levels of technology adoption, namely high technology → high management; high technology → low management; low technology → low management (Nell, Viljoen & Lyne, 1997). Bembridge (1991b) stressed that future technology transfer strategies in South Africa should be based on a target approach to reach progressive, low-access, and resource-poor farmers. Emerging and small-scale black farmers have to be established and provided (equipped) with new technologies as well as management skills to make the best use of these new technologies to compete in a free national and international market (Central Statistical Services [South Africa, Republic], 1985, 1991a; Kirsten, 1994).

Kirsten (1994) gave a total historical background of the approaches to agricultural development in the former "homelands" of South Africa. This background explains the problem encountered with agricultural development as well as the initiatives of the Development Bank of Southern Africa (DBSA) concerning the establishment of Farmer Support Programmes (FSP) at 35 different locations, primarily in the former "homelands" and KwaZulu/Natal. The main philosophy of these FSP's was to supply appropriate support services (transferring the "total new technology package") as well as infrastructure and appropriate institutional support, to black emerging and small-scale farmers with a very low average educational level. It was expected that by providing support services, these farmers would have the opportunity to be exposed to and adopt new technologies. This would hopefully remove or alleviate restricted technical, system-related constraints, allowing a more efficient utilisation of agricultural resources, with a concomitant increase in economic activity and income levels in less developed areas of the country. Van Rooyen (1993) took an overview of the FSP from introduction in March 1987 to 1992, and came to the conclusion that during this period 55 000 people from the former homelands were supported by the 35 FSP's. He also expected that FSP's would expand into a major development strategy in the South African agricultural sector, especially in the rural homelands. With the change of government in 1994, this expectation experienced a major setback in the sense that the Development Corporations, which were the facilitators of the FSP's, were disbanded and their activities carried over to the different provincial Departments of Agriculture who, in most cases, did not have not the capacity to progress with the FSP's. Thus the technology transfer programmes experienced a major setback in the former homeland and rural areas (Claassens, 1998).

The FSP's, which were seen by Van Rooyen (1993) as a huge success were, in fact, not as successful as anticipated because of the absence of one of the major aspects of a successful total support system, namely the holistic approach to development as well as an institution to coordinate such a programme (Kirsten, 1994; Stilwell, 1997).

Düvel (1991) is perhaps the only researcher who did research on the psychological aspects of technology (innovation) transfer and adoption in South Africa. The agricultural

development situation and economic realities in South Africa called for an approach that is priority-orientated, purposeful and efficient. He developed a "revised extension programme model" and offers the biggest scope for improvement in extension directly influenced by a new approach towards behaviour change. In 1994 he developed a model of technology transfer in agricultural development on the assumption that certain "intervening" variables influence adoption behaviour directly, while the influence of more independent variables only show its effect via the intervening variables (Düvel, 1994a). In a further study in 1994 he also developed a model to determine adoption behaviour and found that personal and environmental factors are the independent variables, while needs, knowledge and perception are the intervening variables and adoption of practices and efficiency are the dependent variables. Non-adoption of new technologies can be traced back to unwilling (a lacking need) or incapable (related to aspects of perception and knowledge) to adopt (Düvel, 1994b).

2.4.1 Livestock veterinary technologies in South Africa

External parasite remedies, internal parasite remedies, antibiotics and vaccines are the four main groups of veterinary medicines used by livestock farmers. External parasite remedies were the first of the four major medication groups to receive attention by the veterinary services in the early stages of their formation in South Africa. Scab was the first disease reported in the history of South Africa (Halterley & Litt, 1969). According to Rolando (1990), Europeans were the first to find the new ecto-parasites which were responsible for high losses in livestock production in Natal in 1874. The colonial administration soon realised the need to control these parasites. Samuel Wiltshire was the first veterinary surgeon who came to South Africa for this purpose. He was appointed by Sir Walkins Pitchford from the Natal Colony to assist livestock farmers in combatting East Coast Fever, a tick-transmitted disease (Lawrence, De Vos & Irvin, 1994). The first dipping-tank was installed in 1902 on the farm Baynesfield in Natal. Henning Otto was the first veterinary surgeon sent to the Orange Free State in 1897 to assist livestock farmers in combatting "Rinder pest". The first diseases identified amongst small ruminants in the Free State were scab, blue tongue and quarter evil.

The only study done in South Africa on the attitude of farmers towards livestock medication technologies (internal parasite remedies), was done by Joubert, Van Wyk and De Wet (1994) amongst commercial sheep farmers in the Northern Free State, Northern and North-Western Cape. They found that internal parasites, diseases and external parasites gave the most important problems in their sheep production systems. They also reported that these farmers regard internal parasites with visible effects as the most important ones, and reacted accordingly. In a study done in Namibia on Karakoel sheep, Bembridge and Schimming (1991) found that only 48 per cent of the farmers made adequate provision for disease control and preventative measures. No studies are reported on the adoption of antibiotics in South Africa.

2.3 MODELS AND METHODOLOGIES USED IN THE PAST IN THE TECHNOLOGY TRANSFER AND ADOPTION PROCESS

Two main approaches are followed on the mathematical evaluation of technology transfer and adoption. The first approach is to determine the effect, incentives or the estimation of economic implications of new technologies on the profit of the enterprise or the farm. Operational research techniques are mainly used for these estimations, which require accurate basic information on production levels, production costs, etc. in order to obtain a realistic estimation (solution). The other approach is to determine the variables (predictors) influencing the adoption as well as the rate of adoption of new technologies. In the last approach econometric models (discrete choice models) are used. The rest of this section will deal with econometric models used by other researchers on technology transfer and adoption studies.

2.3.1 Econometric models

Discrete choice (mathematical or econometric) models, in particular the logit, probit, tobit and multinomial logit models, have been widely used to determine the composition of

explanatory variables (predictors) influencing the adoption process of new technologies by farmers. Literature suggests that the farm, the farmer and institutional factors drive farmers to adopt new technologies (Bhattacharyya *et al.*, 1997; Feder, Just & Zilberman, 1985; Nichola, 1994; Wheeler & Ortmann, 1990). Factors such as the financial and socio-economical impacts of new technologies, effects of new technologies on the risk (increasing or decreasing) of the farm, available resources, and technology transfer programmes also have an effect on the decision of the farmer to adopt new technologies (Feder *et al.*, 1985).

When the objective is to identify the socio-economic variables that influence both adoption and intensity (percentage) of adoption, the probit and the tobit models are preferred (Adesina & Zinnah, 1993; McDonald & Moffit, 1980; Nichola & Sanders, 1996). Different approaches towards adoption models that were used in the past were described by Nichola (1994). He refers to the "Innovation Assessment Lag" of Linder, Fisher and Pardey (1979) where the modelling of adoption is seen as a problem of decision-making when there is uncertainty and where learning can occur. This approach assumes that when a new technology becomes available, the farmer does not know if the adoption will be profitable or not, but the uncertainty can be reduced by waiting and gathering information from other farmers adopting the technology. Adoption in this context is, therefore, a function of the subjective belief of the farmer about the profitability (incentives) of the new technology with adjustments as more information and returns on the new technology becomes available.

Feder *et al.* (1985) surveyed various of the more important studies that attempted to explain patterns of adoption behaviour either theoretically or empirically. They came to the conclusion that most aggregate adoption models are dynamic and derive the behaviour of the diffusion process over time analytically. They referred to Mansfield (1961) who derived a S-shaped diffusion path assuming that the driving force of the diffusion process is imitation. They also referred to a number of studies (Lekval & Wahlbin, 1973; Lerviks, 1976; Hernes, 1976) which have extended Mansfield's approach and showed that the diffusion process can be described quite accurately by compact mathematical formulas such as a logistic curve or other specific sigmoids.

Most of the studies on technology adoption as well as that done by Feder *et al.* (1985) were based on the dichotomous qualitative dependent variable ("adoption" or "non-adoption"). Feder *et al.* (1985) referred to Schutjer and Van der Veen (1977) who concluded that adoption cannot be represented adequately by a dichotomous qualitative variable in cases where a package of new technologies is evaluated for adoption. A farmer who is classified as an "adopter" can, for instance, only use one per cent of the new technology and 99 per cent of traditional technologies on his farm. The dichotomous qualitative dependent variable can only be used in those cases where only one or a specific technology is analysed for adoption and where the extent of adoption is not important to the researcher.

Many econometric studies on adoption have focussed on directional impacts of certain explanatory forces rather than their quantitative importance. Feder *et al.* (1985) referred to the studies of Rochin and Witt (1975) and Parthasarathy and Prasad (1978) in this context. An outcome can, for instance, be significant, but the quantitative impact of the variable is unknown. A model must therefore be developed to estimate the coefficients and determine the p-values (i.e. $\leq 0{,}15$) of the predictors.

The linear probability model could be estimated by ordinary least squares. According to Gujarati (1988), the following problems may, however, arise:

- The disturbance cannot be normally distributed.
- The disturbance is heteroskedastic.
- The possibility of $E(P_i)$ lying outside the 0–1 range.
- Estimated standard errors will be biased.
- The usual *t*- tests, etc., cannot be relied upon in small samples.
- The R^2 values will generally be lower.
- It will fit a line with a negative intercept, so that for certain low levels of explanatory variables (X_i), it will yield a negative $E(P_i)$.
- A linear function implies that a given rise in explanatory variables will always result in the same rise in P_i.
- Ordinary least square estimation will still yield unbiased estimators of b_1 and b_2,.

According to Gujarati (1988), one will, in reality, expect that P_i is non-linearly related to X_i. At a very low level of utility or incentive of the new technology the farmer will not adopt the new technology, but at a sufficiently high level of utility or incentive, say, X^* of the new technology, the farmer will most likely adopt the new technology. Any increase in utility or incentive beyond X^* will have little effect on the rate of adoption at both ends of the utility or incentive distribution.

What is needed is a (probability) model that has the following two features: (1) As X_i increases, $P_i = \mathrm{E}\ (Y = 1 \mid X_i)$ increases but never steps outside the 0-1 interval, and (2) the relationship between P and X_i is non-linear. This sigmoid curve resembles the cumulative distribution function of a random variable. One can easily use the cumulative distribution function to model regressions where the response variable is dichotomous, taking 0-1 values (Gujarati, 1988; Thomas, 1996).

Different econometric probability functions or cumulative distribution functions that present a sigmoid curve can therefore be used in the analysis of the adoption process, such as logit, multinomial logit, probit (normit) and tobit analysis. Nichola and Sanders (1996) stated that these discrete choice models are fairly widespread, and referred to Feder *et al.* (1985), Akinola and Young (1985), Akinola (1986) and Adesina and Zinnah (1993). The practical question now is: Which cumulative distribution function should be used? The cumulative distribution functions most commonly chosen to represent the 0-1 response models are (1) the logistic or **logit** model and (2) the normal or **probit (normit)** model. Gujarati (1988) made a comparison between the **logit** and the **probit** models and stated that these two formulations are quite comparable, but the main difference is that the logistic curve has slightly flatter tails than the probit, and the curve approaches the axes more quickly than the logistic curve. Therefore, the choice between the two is a matter of mathematical convenience and availability of computer programmes. According to Gujarati (1988) the **logit** model is generally used in preference to the **probit** model. These two models can only be used when the adoption process is dichotomous (adoption and non-adoption), but a strictly dichotomous variable is often not sufficient for examining the extent and intensity of adoption. A study on adoption with full adopters, partial

adopters and non-adopters, a multiple choice situation (dummy dependent variables), can be better accommodated by a multinomial logit function (Annexure B) (Bhattacharyya *et al.*, 1997 Feder *et al.*, 1985; Park & Kerr, 1990; Studenmund, 1997).

Binary or dummy variables are used to estimate qualitative and non-direct quantifiable variables (dependent and explanatory) in a regression analysis (Nell, 1978; Ramanathan, 1992; Studenmund, 1997). The binary dependent variable can be used to analyse full adopters, partial adopters and non-adopters, and the binary explanatory variables can be used to analyse risk-aversiveness, kind (tenure) of farm, human capital endowments, institutions, information sources, etc.

2.3.2 Conventional and adapted adoption definitions

In the mentioned studies adopters are conventionally defined as farmers who use a specific technology during the survey period. In the theory on technology transfer and adoption the assumption is made that the supply of a new technology (inputs or services) is elastic. However, according to Nichola and Sanders (1996), scarcity of inputs or services can result in a less elastic or even inelastic supply of inputs. Increased costs to obtain new technologies, for instance, caused increased transaction costs for those farmers allocated further away from input or service centres, and can also lead to a less elastic supply function. The absence of subsidies in South Africa makes the classical Von Thünen model of regional economics (Barlowe, 1978; O'Kelly, 1988) relevant to understand the adoption differences between farmers. The price of outputs decreases and that inputs (services) increases as farmers settle further away from input or output markets, which is a continuous relationship as the profitability or incentives of new technologies decreases. The cost of information on new technologies also rises due to increased transportation costs to obtain this information. Many of the variables discussed in this chapter are proxies for decreasing profitability. As farmers are located further away from the urban centre or institutions, it becomes more difficult and expensive to get information on the advantages or incentives of new technologies. If the technology is locally available, farmers who want or need it, will use it. However, if the technology is not locally

available and extra transport costs have an increasing effect on the price of the technology, farmers who want to adopt it, may become non-adopters because they cannot afford it any more.

For these reasons Nichola and Sanders (1996) concluded that the traditional definition of adopters and non-adopters is too restrictive. They argued that under these circumstances the definition of adopters should include would-be or potential adopters. According to them, most diffusion studies have a too narrow definition of adoption when inputs or services are subsidised and rationed as has generally been the case where the state has been promoting the introduction of new technologies, especially for poverty alleviation purposes. In most of the former homelands of South Africa, inputs and veterinary surgeon services were subsidised up to 1994. Because subsidies were stopped, two types of adopters should be used in defining an adopter, namely those actually adopting and those saying that they would have adopted these technologies if they could have obtained these inputs or services (potential adopters).

Henry, Klakhaeng and Gottret (1995) used a logit regression model, following the methods of Hosmer and Lemeshow (1989) to overcome the limitations of the traditional ordinary least squares regression model. This was done to include the estimation of relationships that include dichotomous dependent variables (adoption *versus* non-adoption) (Gujarati, 1988). Grisley and Shamambo (1990) also used a logit model to predict the adoption rate of a bean cultivar. They used tabular and linear correlation methods to identify the characteristics of the households and farms studied and the extent of adoption and diffusion.

Kleynhans and Lyne (1984) analysed factors that had a negative effect on the adoption of technologies. They used selective socio-economic variables that they defer to a discriminant analysis to make a distinction between adopters and non-adopters of new technologies. Swanepoel and Darroch (1991) have also used a discriminant analysis to separate full and partial adopters in their research to determine the characteristics of full adopters of new technologies. Latt and Nieuwoudt (1988) used a discriminant analysis to identify plot size effects on the broad commercialisation concept. The robustness and

less stringent assumptions of discriminant analysis and the interpretability of the results tend to favour its use in this regard. The discriminant analysis can also be used, but the disadvantages of its linearity result in that the natural flow of adoption as expressed by a discrete choice model with its S-curve, cannot be estimated. A further disadvantage is that it cannot accommodate categorical variables.

Hosmer and Lemeshow (1989) suggested the following model-building strategy for the logistic regression:

- The first step is to conceptualise all the possible explanatory variables which may contribute to adoption. The number of variables must be minimised because the resultant model is more likely to be numerically stable, and more easily generalised. The more variables included in the model, the greater the estimated standard errors become, and the more dependent the model becomes on the observed data.
- Explanatory variables that have a logical linkage to the contribution of the adoption of the technology in the study are included in the list of variables. The selection process should begin with a careful univariate analysis of each variable. From this list, possible predictors with a p-value of $\leq 0,15$[1] are determined by means of different statistical tests[2] for inclusion in the econometric models to be estimated.
- Upon completion of the selection of the possible predictors (p-values of $\leq 0,15$), the multivariate analysis using one or more discrete choice models with all the identified variables can be performed.
- The variables from the econometric models with a p-value of $\leq 0,15$ are selected by means of a stepwise regression, as predictors contributing to the different adoption levels estimated.
- The analysis ends with the prediction of the correctness of the classification of the different adoption groups.

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[1] A p-value of $\leq 0,25$ is suggested by Hosmer and Lemeshow (1989), but due to the relative large number of variables (34) and the relative low sample size (in some adoption groups as little as 13) and after discussion with Joubert (1998), it was decided to use a cut-off of $\leq 0,15$.

[2] For the continuous variables the t-test and Mann Whitney tests will be used and for the selection of the categorical variables the Chi-square and Fisher Exact tests.

2.4 VARIABLES (CONSTRAINTS) PREDICTING TECHNOLOGY TRANSFER AND ADOPTION

In this section an attempt is made to identify variables contributing to agricultural technology transfer and adoption. Literature on the adoption of livestock veterinary technologies is very scarce and therefore available literature applicable to the transfer and adoption of crop technologies will also be used as a guideline, amongst others, to identify possible predictors and predictors of livestock veterinary technologies, bearing in mind its differences. The observed rates of adoption indicate that the transfer of new technologies in Third World countries has only been partially successful. The conventional approach is that the constraints, discussed in this section, are the main obstacles in the rapid adoption of new technologies (Feder *et al.*, 1985).

2.4.1 Human capital endowments

The variable "human capital endowments" are perhaps one of the most important groups of predictors of new technology adoption. It includes amongst others, age, family size, level of education, gender, experience, knowledge, management (technical, economical and financial), farming efficiency (technical, economical and financial), farming skills, gender, level of entrepreneurship and creativity.

According to Pinstrup-Andersen and Pandya-Lorch (1997) poverty is one of the main obstacles of sustainable agricultural intensification and development. The International Food Policy Research Institute (IFPRI, 1997) as well as the World Bank (1996) found that seventy to eighty per cent of the 1,3 billion absolutely poor people in the world live in rural areas. These people do not have sufficient human capital capacity (endowments), managerial skills, income or access to credit to purchase and manage appropriate technologies in order to develop a sustainable level of production, protect the natural resources, or rehabilitate degraded resources (Pinstrup-Andersen & Pandya-Lorch, 1994). According to Fényes (1982), Kirsten (1994) and Vink (1986) the same applies for the black South African small-scale farmers in the former "homelands".

Wheeler and Ortmann (1990) as well as Roché (1988) argued that the most important success-determining factors for adopting new technologies are those relating to the human capital endowments (level of education, experience, knowledge, and farming efficiency) and economic status (wealth [i.e. assets], income, land size, and credit use) of the farming household. Formal education and experience are strongly related to knowledge and adoption of production technologies. Bentley (1987) found that although the average formal education of the farmers in the northwest of Portugal was only three to four years schooling their high farming skills helped them to adopt new technologies at a high rate because they responded rationally to economic incentives. The farmers in most Sub-Saharan African countries and most low income Asian and Latin American countries have, in contrast, only gained marginal productivity because of a lack in knowledge.

According to Pinstrup-Andersen and Pandya-Lorch (1997), poor nutrition and health during early childhood have a direct negative effect on the cognitive development of the human brain, which results in low productivity during adulthood. Efficient farming becomes knowledge intensive, and poorly educated farmers cannot take advantage of the rapid evolving technologies to increase the productivity of their farming operations. Pinstrup-Andersen and Pandya-Lorch (1997) suggest that "... developing countries must invest much more in the human resource development of their people, particularly smallholder farmers".

Throughout agricultural history women have played an important role in farming, especially in the cases where the head of the family (the man) earns off-farm income. In the case of Africa, a number of authors (i.e. Gasson, 1994; Jiggins, 1986; Malena, 1994; Sanders *et al.*, 1996) found that women play an even more important role in agriculture than men. Norton and Alwang (1993) reported that in many African countries male farmers tend to be involved in livestock farming, while the women are in charge of crop production.

2.4.1.1 Education and training

2.4.1.1.1 Education

Development of the educational level of a population is required if countries have to domestically produce, adapt, transfer and receive new technologies. According to Lyne (1985), improved education services enhance the adoption of new technologies. Venter, Vink and Viljoen (1993) came to the same conclusion, namely that the low level of educational training is the most limiting factor on technology adoption among small-scale commercial farmers in Venda. Norton and Alwang (1993) concluded that countries that are unable to develop the skills and the knowledge of their farmers and their families find it difficult to develop anything else. The development and utilisation of new technologies and institutions are critically dependent on an educated and developed workforce.

Education is positively correlated to technical progress achieved, although not very strongly (Gibbons *et al.*, 1980). For instance, seventy-five per cent of Malaysians attended secondary schools, whereas only 52 per cent of their counterparts in Aceh in Indonesia attended secondary schools. This also contributes to the difference in technical progress between the two regions, with clear advantage for the most educated farmers (Gibbons *et al.*, 1980). The low educational level of the small-scale farmers in Latin America is perhaps one of the most serious constraints in the process of new technology transfer and adoption and the ability to attain higher income (Peres, 1995). The Programme to Develop Entrepreneurship Abilities in Rural Youth (PROJOVEM) was implemented in Brazil in the beginning of 1997 with the main aim to prepare rural youngsters to manage small farms in a competitive and sustainable way and thus increase the level of income of their families. This programme also comprises the adoption and correct management of new technologies (Peres, 1997).

2.4.1.1.2 Training

Training is one of the most critical factors of the technology transfer process. Cederroth and Gerdin (1986) examined the responses of two local communities in Lombok to the

Green Revolution. In the Karang Sari village, which is situated close to the capital, where the people are not so bound to the traditional way of living and are more informed/trained about technical changes required by the high yielding varieties of rice, the latter was easily accepted. In the Suren village, which is situated much further from the capital, where the people are much more bound to the traditional way of living and not so informed/trained about technical changes required by the high yielding varieties of rice, the introduction of this rice seed was a catastrophe.

Kohnert (1990) feels that the "training and visit" extension approach that is used in development through modernisation, failed in its main goal to transfer technology to the African smallholder in order to increase agricultural production. After five years of experience with the "training and visit" system in West Africa the main goal failed, as innovations were developed by agricultural research stations without due consideration of the particular constraints of the different systems of production and target groups. Claassens (1998) stated, however, that training and visits by the veterinary surgeon, animal health officers and extension officers to enhance the technology transfer and adoption programmes at the sheering sheds in Qwaqwa, played an important role in training the small ruminant farmers in the correct use and adoption of medication technologies up to 1994.

Nagy *et al.* (1988) pointed out that one of the important sections of a support programme for technology adoption is farm management training and demonstration. There are many technologies available that require a greater educational level than that of the farmers. In these cases more educational and training projects are needed to develop the desire for new technologies and its implementation by the farmers (Pritchard, 1986).

In Gambia they adopted the Community-based Experimentation and Extension (CBEE) approach which provides training for the farmers in improved ways of experimentation of new technologies to enable them to proceed with technology development, adoption and management of new technologies on their own (Owens, 1993). The success of the CBEE programme, to a very great extent, depends on the skills and abilities of the field staff or extension officers.

2.4.1.2 Management skills

According to Penning de Vries and De Wit (1987), the fact that potential food production in Sub-Saharan Africa by far exceeds its current production levels, is the main reason why serious agricultural research is being done to develop improved varieties of crops, new husbandry and management technologies that in turn can offer farmers new technologies, better means of production and management. Charreau and Rouanet (1986) pointed out that there are many technologies available for soil and water management as well as agronomic technologies which are not used because of the lack of management skills. Pinstrup-Andersen and Pandya-Lorch (1997) also found that because of the lack of management skills, the farmers in most Sub-Saharan African countries and in most low income Asian and Latin American countries, have only gained marginal productivity. If applied and managed correctly, they can have a significant impact on agricultural production.

In 1976 a total of 10 146 families were settled in the Mahaweli Ganga Development Project in Sri Lanka. After three years it became apparent that the project's objectives were getting awry. After an assessment of the reasons for that situation it was found that the settlers had an acute absence of productive and managerial human skills. In other words, they were not able to adopt and manage the new technologies transferred to them (Kahn, 1982). Peres (1995) feels that the only way in which these problems can be overcome is by giving the small-scale and emerging farmers competence to manage their farms, whereas the agricultural school system in Latin America could improve the standard of living as well as the managerial skills of the peasants. The development of techniques for small farm management is of utmost importance in order to help with the agricultural development of the small-scale farmer.

Future technologies will need to include improvements in resource management (soil fertility, water, veld and capital management) (Sanders *et al.*, 1996). In Sub-Saharan Africa the most successful technology change took place in Burkina Faso, Mali, and Senegal where the introduction of new cultivars was very successful due to improved crop

management techniques adopted by the farmers. It can therefore be concluded that when farmers start to use more complex management systems and the results are positive, they will be more open to further improvements, especially if the overall economic environment for increased crop production is favourable.

2.4.1.3 Level of entrepreneurship and creativity

Gibbons *et al.* (1980) concluded that once the regional and ethnic variables are held constant, progress in entrepreneurship emerges as the most discriminating expression of the Green Revolution. The entrepreneurial farmer will adopt new technologies at a higher rate than the non-entrepreneurial farmer. Entrepreneurship explains the largest proportion of the variances in farmer participation (technical progress) in new technologies. It is the active, well-informed entrepreneurial farmer, the one who seeks credit, subsidies, new technologies, etc. who first adopts new technologies. They also found an existing inherent positive relationship between entrepreneurship, farm size and technology adoption.

Mills (1994) reported that the level of entrepreneurial activities and skills of small-scale fish farmers played a major role in the adoption of new fish technologies and in the expansion of fish farming activities in Sub-Saharan Africa, especially in Malawi. In comparing black commercial farmers with black subsistence farmers, Nicholson and Bembridge (1991) found that the level of innovative and entrepreneurial skills of the commercial farmers were much higher than those of the subsistence farmers, even though the commercial farmers are farming on poor subsistence land. According to Bembridge (1991a) the availability of credit and entrepreneurial skills had a direct effect on innovativeness and yield per hectare. In the same study it was found that innovativeness can be predicted by the level of understanding of a practice. The urge among small-scale avocado farmers in Venda to increase their entrepreneurial and managerial skills in order to improve the implementation of new technologies to increase their productivity, was evident in the study done by Bembridge (1992).

Clarke (1996) is of the opinion that initiative, the desire to succeed, the ability to determine priorities, tenacity and persistence to face obstacles and willingness to move into action distinguishes the entrepreneur from the non-entrepreneur. Research shows that the entrepreneur:

- enjoys identifying, evaluating and developing opportunities;
- responds quickly to changes;
- has energy and drive;
- has confidence in his or her own ability;
- is enthusiastic and focuses on the positive;
- is an excellent communicator;
- has good social interactions;
- has knowledge and experience in the field of farming practice he or she is in;
- is self-disciplined and committed towards making new technologies work; and
- enjoys good health.

2.4.2 Farm size/herd size and annual income

Reed and Salvacruz (1995) came to the basic premise that large farmers have a greater margin of risk-taking and greater access to capital (spendable money) which enables them to shift to new technologies sooner than the smaller farmers. This increases the gap between these two groups of farmers, which implies that the channels for credit to modern inputs for small farms should be improved. If the infrastructure and the necessary assistance (access to credit) are in place the misconception that a large farm structure is essential for the adoption of new technologies, is proven wrong. Henry *et al.* (1995), in their study on the adoption of new cassava varietal technology in Thailand, found that the adoption was higher on relatively large farms and in more fertile areas. This finding was also in line with those of Feder *et al.* (1985) in a comparative adoption analysis. Latt and Nieuwoudt (1988) found the same in a study in three rural regions in KwaZulu/Natal. Farmers with larger plots were able to sell more produce and they made more use of improved technologies. Swanepoel and Darroch (1991) came to the same conclusion from

research done in the same province, as they found that the adoption of new technology packages were higher among farmers who belong to older "clubs"[3], have less formal savings, receive more visits from extension officers, have larger farm sizes and a higher rand monetary value on livestock. Larger farms reduce transaction costs, which increases the economic advantage and incentives of new technologies.

Gibbons *et al.* (1980) reported that of the 97 million agricultural holdings in Asia in the early 1960's, 45 million (46%) were under one hectare in size and 21 million (21%) were between one and two hectares (see also United Nations, 1976). The larger farmer entrepreneurs had the capacity and ability to exploit new technologies and aid at a higher rate than the small farmers. The net return per unit of cultivated land to technical progress and Government Agricultural Aid (GAA) (physical infrastructure; extension; receipt of inputs; receipt of credit or subsidies; assistance with marketing/processing; membership in agro-based organisations), has been greater for larger farmers.

One of their final conclusions was that in order to develop farmers to a level where they are able to exploit new technologies, land development and redistribution programmes must be designed to give every farming family access to enough land to enable them to produce enough to rise above the poverty line.

Gibbons *et al.* (1980) came to a final conclusion that technology transfer, adoption and progress on their own cannot improve the returns of small farms. These techniques can also not be used on their own, to overcome the pre-existing inequalities in the distribution of farm size and tenure. They said that "GAA and technical progress are largely responsible for the increasing inequality evident in both study regions, because of their impact, they favour the larger farmers". GAA and technical progress actually aggravated the pre-existing inequalities (enlarging the "gap" between "poor" and "rich farmers").

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[3] Farmers form a group through which they buy inputs and market outputs in order to get discounts and obtain higher prices for their products because their bargaining power increases.

In Malaysia where technology transfer was more successful, the net results in relative and absolute terms were much higher than in Indonesia. The average "small" farm in Malaysia generates a surplus of approximately 17 guintals in comparison with Aceh (Indonesia) of less than one guintal and even the "large" farms only generates seven guintals. In Aceh the purchase per hectare of all inputs drops remarkably with an increase in farm size, while in Malaysia it rises. These facts again enlightens the effect of better technology transfer (Gibbons *et al.*, 1980). Griffin (1974) found in his study in Java and in the Philippines that larger farms in Java tend to use more inputs, while in the Philippines he found the opposite. In the Philippines "fertiliser is largely a substitute for land", meaning that an increase in the use of fertiliser produced better results than land expansion.

Inequalities in farm size will always exist in any free economy. People are not the same, therefore equal development will never occur (Ruttan & Hayami, 1984). Gibbons *et al.* (1980), however, do not agree because they found that farm size is relatively unimportant when it comes to the usage of agricultural aid (extension, infrastructure, inputs, credit, assistance with marketing and membership in agro-based organisations). Where new technologies are available and the opportunity exists, farmers take advantage of it and adopt and use it. The early adopters are normally those who get the highest remuneration for adopting new technologies (Binswanger & Von Braun, 1993).

Kleynhans and Lyne (1984) concluded that the arable land area per permanent family member was the most important factor that had a positive effect on technology adoption and that the number of cattle owned by the family was the second most important socio-economic factor influencing technology adoption. The contrary was found by Otsuka and Delgado (1995) who stated that although socio-economic factors such as farm size and tenure are often considered as critical determinants of technology adoption, there is no evidence to support such views (see also David & Otsuka 1994; Otsuka *et al.*, 1994).

In his study on the effects of new technologies on farm equity, Shand (1987) found that technology in itself is scale-neutral. Shand also referred to studies done by Hayami

(1981), Kalirajan and Shand (1982) and Vyas (1982) who came to the same conclusion. There were substantial income gains to the farmers arising from crop intensification and the introduction of new production technologies which were obtained without any significant alteration of distributional equity of farm income.

2.4.3 Traditional farming practices

The historical "Trás-os-Montes" farming systems in Portugal have been sustained and developed through indigenous knowledge and not by "modern" science and technology. Portela (1994) argues that the development of indigenous knowledge can be used to sustain the natural resources and will not damage the natural resources and environment like "modern" technology. In a traditional farming system the farmers use their knowledge to generate their own technologies and transfer it amongst themselves very effectively.

In a research done by Sanders *et al.* (1996) where new technologies and traditional technologies were modelled, they compared three situations: (1) perfectly inelastic land supply – severe land degradation and population pressure; (2) moderately inelastic land supply by introducing time, cost of travel and moderate population pressure, and (3) perfectly inelastic land supply which was modelled by fixing the supply of bush-fallow land at 3,5 ha per farm. In all three cases the new technologies resulted in significantly higher annual net farm income, which indicates that it is very difficult to "turn the clock back" in a modern economy like South Africa.

2.4.4 Extension

Extension visits or availability of extension services is perhaps the single variable (predictor) that emerged significantly in most of the research work on technology transfer and adoption. According to Mijindadi (1995), the following lessons may be found useful from experiences concerning technology transfer of Nigeria's extension services:

- Effective extension services with a good extension approach and well-trained and experienced extension officers would put pressure on the research systems to become more farmer demand-orientated and transfer new technologies more efficiently.
- Extension advice on its own cannot develop a nation's agriculture.
- A combination approach to extension services must be followed.
- Specific extension programmes for women and using a group extension approach has been shown feasible and helpful.
- For an extension programme to be sustainable, a total political commitment at the very top is essential.

A strong technical institutional basis is essential if agricultural extension services in African countries are to be sustainable in the long run and assist in the technology transfer and adoption process.

Of the six types of GAA to paddy and rubber smallholders considered in the research, extension programmes were, according to Gibbons *et al.* (1980), identified as the most important type of aid, but the small farmers targeted, rated their impact as very low. Unfortunately the shortage of trained and experience extension personnel resulted in the small portion of smallholders reached by the programmes of the Green Revolution. This in turn resulted in the uneven distribution of technology transfer and adoption amongst the small farmers. The availability of extension services was positively correlated with technical progress. Wellard and Copestake (1993) concluded that where governments in Sub-Saharan Africa had effective extension services, the technology transfer and adoption processes were very succesful and the quality of life has increased at a remarkable rate.

The availability of appropriate technology and extension services is essential in the establishment of profitable agricultural enterprises (Binswanger & Deininger, 1996). Kirsten (1994) referred to Eicher and Baker who came to the conclusion that over the past 20 years in Africa, most extension services and officers have been poorly equipped and undertrained, when compared to their counterparts in Asia or Latin America. Most

extension services in Africa are orientated toward technical problems and ill equipped towards farm management or social aspects that are necessary for technology transfer and adoption. Nagy *et al.* (1988) found that experienced extension officers are one of the most important components of technology transfer and adoption support programmes.

2.4.5 Attitude towards risk

Birowo *et al.* (1989) reported that risk-aversion was one of the basic constraints towards adoption of new technologies in Indonesia. According to Sanders *et al.* (1996), profitable agriculture is essential if one wants to hasten the adoption and diffusion of new intensive technologies. In their modelling on intensive technology introduction they found that risk-aversion had a minimal effect on intensive technology introduction in the cases analysed, the most likely reason being the low risk-level of the technologies introduced. Binswanger (1980), on the contrary, found that farmers who are risk-averse will seek risk-reducing strategies and technologies to adopt in their farming systems. That is why small-scale farmers and emerging farmers will implement technologies that do not necessarily give maximum net returns (Dillon, 1986). Sanders *et al.* (1996) concluded that farmers who consider adopting new technologies, tend to be pessimistic about possible yield gains until they have more information on the results of new technologies. This factor may be more important than risk-aversion as an impediment to higher diffusion rates.

2.4.6 Access to credit

An important aspect of a support programme is the functionality of credit programmes to adopters of new technologies (Nagy *et al.*, 1988). Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies. The nature of livestock production systems is not as capital intensive as crop production systems, which makes the availability of credit to buy veterinary technologies less important than for crop technologies, especially medication technologies where the medication to be purchased is

not so capital intensive. However, if the farmer wants to purchase registered or graded rams, access to credit can play a more important role.

According to Pinstrup-Andersen and Pandya-Lorch (1997) there is, however, an urgent need for effective credit and savings institutions in rural areas to enable small-scale farmers and emerging farmers to invest in new modern technologies and sustainable agricultural intensification. Birowo and Qasem (1987b) further argued that extended credit policy made it possible for farmers in Indonesia to increase input purchases (mainly fertiliser and pesticides) and an appropriate price policy (subsidies) stimulated farmers to adopt new rice technologies.

Desai, Gupta and Singh (1988) came to two major conclusions in their study on technology adoption in India, namely that agricultural progress and the volume of credit are positively related, and credit repayment among cooperatives is positively related to the level of agricultural progress. Charreau and Rouanet (1986) stressed that the availability of credit is a precondition for persuading farmers to adopt new technologies. In the Ukraine the major constraint in adopting new technologies by farmers is the access to credit or financing (Sohatsky, 1995). This finding is shared by Coetzee, Kirsten and Van Zyl (1993) as well as Venter *et al.* (1993) who found that credit was much more important to emerging commercial farmers (who have adopted more modern technologies) than to subsistance and sub-subsistance farmers in South Africa.

One of the main problems in South Africa is the cost of credit as well as the relatively high transaction costs of production loans obtained through the South African Land Bank to acquire new technologies in crop and livestock production. The interest rate on production loans (between R5 000 and R60 000) is at present higher than 20 per cent. With such high cost it is very difficult to repay debt under the current agricultural circumstances in South Africa (Van Zyl, 1997).

2.4.7 Information sources for decision-making

Acquisition of information is one of the important aspects in adoption studies (Feder & Slade, 1984). Bhattacharyya *et al.* (1997) refer to Putler and Zilberman (1988) and Zepeda (1990) who reported that farmers in the United States of America using computers as information source, tend to adopt new technologies at a higher rate than farmers not using computers. Bhattacharyya *et al.* (1997) did a study on the rate of adoption of *Trichomoniasis* vaccine amongst range cattle farmers in Nevada, and found that cooperative extension programmes enhance the rate of adoption.

2.4.8 Infrastructure and institutions, input and output markets

Both Pinstrup-Andersen and Pandya-Lorch (1997) and Venter *et al.* (1993) reported that inadequate infrastructure and marketing facilities are the key barriers to technology adoption and usage. Pinstrup-Andersen and Pandya-Lorch (1997) also indicated that the poorly performing agricultural extension systems, the declining investment in agricultural research, inadequate infrastructure and marketing facilities and a lack of incentives to appropriately used inputs had a negative effect on the adoption of technologies. Venter *et al.* (1993) came to the same conclusion that the absence of the mentioned infrastructure contributes a great deal to a low level of technology adoption in Venda.

To facilitate the introduction of new technologies, governments must assist the potential types of useful research and extension institutional support programmes (Nagy *et al.*, 1986:66). This will help to expand the technology transfer process and spread it in the shortest possible time to the highest number of farmers. Nagy *et al.* (1988) rated the subsidisation of inputs and development of the input and output market, as well as functional infrastructure, as important components of support programmes for technology transfer and adoption.

A highly-developed infrastructure for information flow, a functional interactive system of region-based input and output markets and favourable consumption incentives are essential components of a good technology transfer programme and agricultural growth (Mellor, 1990).

Pinstrup-Andersen and Pandya-Lorch (1997) further stressed that governments must provide the infrastructure needed for emerging and small-scale farmers to deal in their disadvantages on a free national and international market, otherwise these farmers will face a constant deterioration of their farming operations. They concluded by saying that adoption and use of new technologies alone will not be sufficient for the emerging and small-scale farmers in the developing world to survive the rapid change in technologies, but they must also be provided with appropriate policies that go hand in hand with new technologies. Van Zyl and Kirsten (1992) came to the same conclusion that production oriented policies that imply technological change and commercialisation of production by rural households, as well as the necessary infrastructure, will provide a long-term impact for all the food security risks.

According to Sanders and Shapiro (1998), improved economic policy, infrastructure and institutional structures have a positive effect on the adoption, diffusion and utilisation of new technologies through increased incentives. The Sub-Saharan African countries need to find new approaches (incentives) as well as technologies to counter the price collapse problem, especially of staple food crops in good production years.

2.5 CONCLUSION

Technology forms an integral part of a total agricultural development system. If it was not for the development and adoption of new technologies in agriculture, the world would have been starved today, as predicted by economists two centuries ago. With the present population growth rates, especially in the developing world, the implementation of improved technologies and bioengineering are essential in increasing the world's food production and supporting the ever-increasing world population growth.

The discussion of technology transfer and adoption on the international arena, and especially in the developing world (Asia, Latin America and Sub-Saharan Africa), in most of the cases showed a great improvement in food production and poverty alleviation, but also a lack of a holistic approach to ensure sustainable agricultural development

programmes. The Green Revolution in Asia, on the one hand, was very successful in the sense that it improved agricultural food production, but the absence of ecologists on its programmes had a degrading effect on the natural environmental resources (land and water). Again the absence of a total system (holistic) approach placed a question mark on the sustainability of the Green Revolution. Belloncle (1989) stressed a commonly held view that when innovations (technologies) are technically feasible, sociologically acceptable, and economically profitable, as well as functional infrastructure and effective institutional structures, African farmers will quickly adopt them. Gibbons *et al.* (1980) found that if productive incentives of new technologies are implemented and available, farmers will adopt it and use it. Policy changes and institutional reform have to accompany and support technology diffusion programmes to ensure satisfactory adoption levels.

The conclusion on the literature on technology transfer and adoption with women farmers was that the importance of women farmers and their specific role in the developing agriculture was not acknowledged in the planning and development stage of new technologies. A further aspect that was uttered was the importance of the training of women extension officers to assist women farmers with extension services (Jiggins, Maimbo & Masona, 1992) . The relevance of traditional agriculture was also discussed and the main conclusion was that it can play an important role in an underdeveloped economy and in livestock medication technologies where the necessary herbal plants are available in the area of farming.

South Africa is situated in a unique position in Africa concerning technology planning, development, transfer and adoption in the sense that roughly 86 per cent of the agricultural produce are produced by commercial farmers with highly developed technologies and the other 14 per cent by developing and subsistence farmers who are not in the position to obtain and use these highly developed technologies due to a lack of knowledge and financial capacity and not always having the necessary infrastructure and institutional structures available to support them (Fényes, Van Zyl & Vink, 1988).

From the literature review it is evident that the lack of research on livestock veterinary technologies, and especially adoption of veterinary technologies, are of great concern and need more research. It is evident from the discussion in this chapter that knowledge regarding variables on livestock veterinary technologies is very low. In the following chapters the focus will be on identifying these variables.

The theoretical description of the models that will be applied in the analysis of the data will be described in Chapter 3 as well as the conceptualisation of the explanatory variables that will be used in the models.

Chapter 3

DESCRIPTION OF METHODS AND VARIABLES USED

3.1 INTRODUCTION

In this chapter the methods used to analyse adoption and levels (categories) ov livestock veterinary technologies are discussed. The methods used with the selection of the variables, their justification, as well as the way the data was collected, analysed and modelled will also be attended to in this chapter.

In the first section of this chapter a short justification of the different dependent variables and a conceptualisation of the explanatory variables are given. This is followed by a short description of the survey, which includes a short discussion of the study area, sources of information used, the development of the questionnaire, the sampling technique used and the data collection. The chapter concludes with a description of how the data was processed, which includes the methods followed in the selection of the possible predictors and a brief description is given on the discrete choice models used in this study with the determination of predictors.

3.2 SELECTION OF VARIABLES

No precedent exists to provide a guide in the selection of relevant variables (predictors) to either replicate or refute previous results on livestock veterinary technology adoption.

This necessitated the use of a larger number of explanatory variables considered in the models than would have been done under normal circumstances, with previously available

information from reference studies. Most of the variables included in the different adoption models considered in this study were selected from the literature in Chapter 2. Unfortunately, most of the existing diffusion/adoption studies on new agricultural technologies are on crop production (Feder, Just & Zilberman, 1985; Grisley & Shamambo, 1990; Henry, Klakhaeng & Gottret, 1995; Lin, 1995; Nichola, 1994; Park & Kerr, 1990), except for the research done by Bhattacharyya *et al.* (1997), which refers to the adoption of a vaccine (against Trichomoniasis) on range beef cattle in Nevada.

The limited number of reference studies compelled the author to construct a panel of experienced specialists to identify adoption categories and variables which may probably affect the adoption of livestock veterinary technologies. The panel consisted of five veterinary surgeons, three animal scientists and four extension officers (some of which were previously involved in the diffusion of livestock programmes in Qwaqwa up to 1994). The hypothesised variables are discussed in the following section.

3.2.1 Dependent variables

The dependent variables tested in this study can broadly be divided into two categories, namely adoption of veterinary surgeon services technology and medication technologies. The medication technologies are further divided into four major groups of medicine, namely external parasite remedies, internal parasite remedies, antibiotics and vaccines. Different categories (levels) of livestock veterinary technologies were generally identified as follows:

- ***Non-adopters:*** Farmers who do not use a specific livestock veterinary technology at all.
- ***Adopters:*** Farmers who use a specific livestock veterinary technology.
- ***Full adopters:*** Farmers who use a specific medication technology at a recommended level.
- ***Partial adopters:*** Farmers who use a specific medication technology, but at a lower level than recommended.
- ***Over-adopters:*** Farmers who use a specific medication technology at a higher level than recommended.

- ***Potential adopters:*** Farmers who are non-adopters of a specific livestock veterinary technology, but want to use it or would have used it had it been available and/or accessible.
- ***Wrong adopters:*** Farmers who only use wrong medication technologies for a certain disease.

For each of the livestock veterinary technologies studied, the farmers were classified into the different general adoption categories mentioned. A more specific definition for the different adoption categories will be given in Chapters 5, 6 and 7 for each of the livestock veterinary technologies. The adoption categories were grouped for each of the livestock veterinary technologies and their characteristics (variables) compared under the hypothesis that they differ significantly.

3.2.1.1 Veterinary surgeon services

Veterinary surgeon services in this study refer to the services rendered by a veterinarian to the farmer. These services must include a clinical intervention by the veterinarian directly on small ruminants at the farm or at any other place where the veterinarian was visited.

Three categories of adoption can be identified for veterinary surgeon services, namely (i) **non-adopters** and (ii) **adopters**, as described by most researchers in conventional adoption studies (Feder *et al.*, 1985; Lin, 1995; Park & Kerr, 1990) and (iii) **potential adopters** for a less elastic/inelastic supply of inputs or conditions of services (adapted definition), as suggested by Bhattacharyya *et al.* (1997) and Nichola and Sanders (1996), as it is hypothesised to be the case in Qwaqwa[1].

Both adoption definitions (conventional and adapted) were tested and compared, using logit models, to determine predictors for the adoption of veterinary surgeon services. These discrete choice models have been widely used by several other researchers in studies

[1] Fully subsidised government veterinary surgeon services were available free of charge at the sheering sheds up to 1994. Only a private veterinary surgeon is at present available in Phuthaditjhaba for three hours per week where transportation cost is up to R250 (100 km @ R2,50/km). If a farmer has to travel to Harrismith to the private veterinary clinic, the transportation cost doubles to R500 per trip.

on the adoption of agricultural technologies (Bhattacharyya *et al.*, 1997; Feder *et al.*, 1985; Lin, 1995).

Two logit models are constructed, one in which potential adopters are grouped with non-adopters and compared with adopters (conventional definition), and another model where potential adopters are grouped with adopters and compared with non-adopters (adapted definition).

3.2.1.2 Adoption of medication technologies

The medication technologies considered in this study, are divided into four basic groups or types of medication, namely (i) **external parasite remedies**, (ii) **internal parasite remedies**, (iii) **antibiotics**, and (iv) **vaccines**. The *IVS Desk Reference Book* (1998) was used to classify the medicines reportedly used by the farmers in the four medication groups considered. If remedies which have a simultaneous effect on more than one group (e.g. Ivermectine 1%) are used, then farmers are considered adopters of both medication groups (external and internal parasite remedy).

3.2.1.2.1 Adoption of external parasite remedies

In this study external parasite remedies refer to medication drugs used to control skin parasites like ticks, mites (scab) and lice. According to Agri-Mark's annual sales figures of Qwaqwa, external parasite remedies have the **highest** sales of the four medication groups discussed in this study (Venter, 1998).

Different numbers of applications of external parasite remedies are recommended for different regions of the country, depending on the local conditions. The categories of adoption of external parasite remedies can be defined as, (i) **full** and **over-adopters** and (ii) **partial adopters**. Over-adoption of external parasite remedies have no major consequences, besides being a waste of money that could be used in other technologies (Erasmus, 1998; Naude, 1998). As this study deals with the identification of predictors contributing to adoption and is not an economically viable study on technologies, it was decided to group this category with that of full adoption. The usage of wrong remedies

(e.g. HI-TET) in combination with a correct remedy for external parasites, according to Erasmus (1998), is not a major issue, therefore these cases will be classified as adopters.

3.2.1.2.2 Adoption of internal parasite remedies

Internal parasite remedies, in this study, refer to livestock medication drugs used to control internal parasites such as roundworm, tapeworm, nasal worm and liver fluke. These drugs (applied by injection or dosed orally) have a therapeutic effect over already present parasites; however, when used regularly and in an adequate programme, they may have a preventative effect on internal parasite diseases (Van Schalkwyk, Van Wyk & Viljoen, 1995). According to Agri-Mark's annual sales figures of Qwaqwa internal parasite remedies have the **third highest** sales of the four medication groups discussed in this study (Venter, 1998).

A certain number of applications of internal parasite remedies are recommended over a year for different regions of the country, depending on the local conditions. Three adoption categories can be distinguished for this dependent variable, namely (i) **partial adopters**, (ii) **full adopters** and (iii) **over-adopters**. The incorrect use of internal parasite remedies (partial or over-adoption) may have serious implications as the induction of resistance against these drugs (Vermunt, West & Pomroy, 1996). For this reason it is very important to analyse the characteristics of these adoption categories separately.

3.2.1.2.3 Adoption of antibiotics

Antibiotics in this study refer to systemic and local antibiotics used to treat sick animals, including eye and wound remedies containing antibiotics. Antibiotics have a therapeutic effect and may be of great importance in lessening the mortality rate among sick animals. According to Agri-Mark's annual sales figures of Qwaqwa antibiotics have the **second highest** sales of the four medication groups discussed in this study (Venter, 1998).

Antibiotics are recommended in only visibly affected animals for infectious conditions caused or aggravated by most bacterial diseases. Three adoption categories with regard to the dependent variable have been identified, namely (i) **non-adopters**, (ii) **partial adopters** and (iii) **full adopters**. For this medication group it makes no sense to consider

an over-adoption category, as there are no recommended programmes for the usage of this medication.

3.2.1.2.4 Adoption of vaccines

Vaccines in this study refer to biologic veterinary products that are used in animals as a preventive (prophylactic) measure to prevent disease. Vaccines are the only type of medication amongst the four medication groups considered in this study that has a prophylactic effect (Hunter, 1993). According to Agri-Mark's annual sales figures of Qwaqwa, vaccines have the **lowest** sales of the four medication groups discussed in this study (Venter, 1998).

According to Schwalbach (1998), each area of the country has a basic recommended annual vaccination programme, defined by veterinary services on the basis of the existing information on the local prevalence and incidence of diseases of economical importance. Two adoption categories with regard to this dependent variable have been identified, namely (i) **non-adopters** and (ii) **partial adopters**.

3.2.2 Explanatory variables

The purpose of this section is to describe the selected variables to be tested in the different livestock veterinary adoption models. All the explanatory variables selected from the literature that were measured in a slightly different way in this study, as well as all the variables (more related to livestock technologies for developing farmers) selected by the panel of livestock experts, are briefly discussed in this section.

It is possible to classify and use some variables either as **continuous** or as **categorical variables**, depending on how a variable is approached or measured. An example, for instance, is extension visits which can be classified as a continuous variable if number of extension visits per year is measured, or as a categorical variable if the researcher is only interested in whether the farmer received extension visits or not. The following explanatory variables were used to determine predictors contributing to adoption of the different livestock veterinary technologies considered in this study (veterinary surgeon services and four major medication groups):

3.2.2.1 Continuous variables

These variables take any numerical value in a real interval when measured accurately (Ramanathan, 1992):

- Age of the farmer.
- Number of people in household.
- Educational level of farmer.
- Years of farming experience with livestock.
- Farming efficiency (median weighted weaning percentage of small ruminants).
- Management skills – planning (median days planned ahead).
- Level of entrepreneurship.
- Livestock income per livestock unit (LSU).
- Herd size.
- Mortality rate* (mortality as percentage of total small ruminant herd size).
- Total indebtedness of the farmer irrespective of the origin of the debt.
- Number of extension officer visits per year.
- Reasons for farming*.
- Type of small ruminant farmer*.

* Variables identified by the panel of livestock experts.

3.2.2.2 Categorical variables

These variables take a numerical value of one or zero and are also called binary or dummy variables (Annexure B.4).

- Attitude of farmer towards risk.
- Literacy and arithmetic abilities of farmer.
- Gender.
- Traditional medication or remedies used (herbs and plants).
- Training sources approached on medication usage (extension sources, co-farmers, media and own sources).
- Record-keeping.

- Level of income and cost record-keeping.
- Availability of credit.
- Information sources approached to make technical decisions.
- Information sources approached to make financial decisions.
- Information sources approached to make marketing decisions.
- Sources approached to get information on new technologies.
- Availability and accessibility of roads.
- Availability and accessibility of transport.
- Availability and accessibility of telephone.
- Availability and accessibility of electricity.
- Availability and accessibility of local markets.
- Availability and accessibility of government and cooperative extension and agricultural research institutions.
- Availability and accessibility of suppliers of inputs institutions.
- Usage of mating seasons*.
- Usage of registered and grade rams*.
- Location of farmer/farm* – Old or New Qwaqwa.

* Variables identified by the panel of livestock experts.

Some of the variables (e.g. age, education and extension visits) were used directly as identified from the literature on crop technology transfer and will not be discussed further in this chapter. Another group of variables selected from the literature, but measured in a different way (e.g. farm size/herd size, management skills, farming experience and farming efficiency) or others identified by the panel of livestock experts which need proxies to be quantified and those identified by the panel of experts referred to earlier, will be briefly described and discussed in this section.

❑ Human capital endowments

In this study human capital endowments include the following explanatory variables:

- Age.
- Family size.
- Education.
- Gender.
- Knowledge.
- Farming skills or experience.
- Farming efficiency.
- Management skills.
- Level of entrepreneurship and creativity.

The variable "**education**" is measured in terms of the highest grade the farmer has achieved in formal education. Gender will be included as a categorical variable, which is one if the farmer is a women and zero if otherwise. Knowledge is proxied as a categorical variable with literacy and arithmetic abilities. The specifications and dosages of medication are printed on containers in English and/or Afrikaans. It was hypothesised that farmers who can read Afrikaans or English and can make basic calculations (add, subtract and multiply) would be more able to use medication technologies than illiterate or poor arithmetic skilled farmers. The dummy variable is a one for farmers with the above-mentioned abilities and zero if otherwise. The variable "gender" will be included as a categorical variable if the number of women farmers are sufficient to do a statistical analysis. If the head of the farm is a woman, a one will be scored and a zero if otherwise.

Farming skills or experience is proxied by the number of years of farming experience with livestock. Farming efficiency is proxied with a weighted average weaning percentage of the different small ruminant herds kept by the same farmer (the weaning percentage of a larger herd carries a higher weight in the calculation). Weaning percentage is one of the most important efficiency parameters for the small ruminant farmer because it includes fertility, conception rate, lambing percentage and mortality rate (Greyling, 1998). It measures technical efficiency.

Management skills are proxied by the number of days that the farmer is planning ahead. Giles and Stansfield (1990) refer to planning as an integral part of management. Most

medication activities of the small ruminant farmer are actions that must be taken according to a management programme (prophylactic) made in advance, which include the treatment for internal and external parasites as well as vaccination against diseases. This programme is highly dependent on the seasonal variations of climatic conditions that play a determinant role in the epidemiology of different animal diseases over the year. This makes planning ahead a very important component of a successful small ruminant operation.

The **level of entrepreneurship** is measured by means of two questions under each heading. The results were added and weighed according to a scale to develop an entrepreneurial index which was used in the models as a variable. A set of statements included in the questionnaire to evaluate entrepreneurial skills were developed from literature on evaluation of entrepreneurial skills (Bird, 1989; Cromie & O'Donaghue, 1992; Maasdorp, 1992) with the assistance of Human (1997). These questions (Annexure A, Section B.8) were refined and tested in Qwaqwa in collaboration with Komako (1998). These statements tested leadership, need for goal achievement, creative skills, motivation to progress, need for autonomy and attitude towards risk.

❑ Farm/herd size - Annual livestock income per livestock unit

Herd size as well as total annual livestock income are scale variables. It is obvious that larger farms or farms with a higher income are more likely to adopt new technological inputs. This is trivial for this study. The difference in tenure between farms in Old (communal) and New Qwaqwa (commercial) makes it difficult to work with farm size or the area utilised by each farmer. The number of small ruminants can also not be linked to their feed intake to compute the grazing area used, due to the overgrazing problem in Old Qwaqwa. Total annual income per LSU (which includes own consumption) as a measurement of financial efficiency, will be used instead of total farm income. This will counter the problem of scale variables that tend to dominate other variables in a model. The total small ruminant (LSU) herd size will be used as variable to determine the effect of the fixed cost part of transaction costs in the adoption of livestock veterinary technologies.

❑ Mortality rate

Mortality rate is one of the parameters indicating technical efficiency in a livestock farming enterprise (Devendra & McLeroy, 1982) as it has a direct effect on the number of marketable animals. It is hypothesised that farmers experiencing higher mortality rates will also be the ones with a lower adoption rate of livestock veterinary technologies. On the other hand, higher mortality rates can motivate farmers more to adopt livestock veterinary technologies than those with lower mortality rates. No previous adoption study could be found that has considered this variable.

❑ Extension visits

Extension services form part of the institutional explanatory variables. Extension is perhaps one of the most important ways of transferring information to a farmer (Wheeler & Ortmann, 1990). This variable is measured by the number of extension visits that the farmer receives in a year at the farm or at the shearing shed.

❑ Reasons for farming

Another variable that did not receive attention from researchers on technology adoption studies, is the reason why farmers are farming with small ruminants. Farmers were asked to rate different reasons for farming with small ruminants (from 4 as very important to 1 as not important) (Annexure A, section E.6) . The rates given by farmers for farming for normal purposes (commercial reasons) were analysed, as it is hypothesised that farmers who are more commercially orientated, will rate it important to very important and will have higher adoption rates than subsistence farmers who will rate it as not important. It is assumed that most farmers in developing countries have commercial objectives; however, in traditional African production systems it is often reported that the main objective for farming is social prestige and to invest in capital which is easily converted into money (Diomisio, 1985).

❑ Type of small ruminant farmer

It was decided to include the variable "type of farmer", because it was hypothesised that the kind of small ruminant farmer will have an influence on the adoption of medication technologies. Sheep are hypothesised to be more susceptible to diseases than goats. This variable is expressed as sheep LSU's (mutton and woolled) as percentage of total small ruminant LSU's in the herd.

❑ Kind (tenure) of farm (location of farming operation)

The location of the farm or farming activities in Old and New Qwaqwa is important for this study because of the different tenure systems in the two areas of Qwaqwa (Chapter 4). The variable is a one if the farmer is from Old Qwaqwa and a zero if the farmer is from New Qwaqwa.

❑ Attitude towards risk

The attitude towards risk in this study refers to the farmers' attitude towards profit flow (Annexure A, section D.7). A risk-seeking farmer is the one willing to spend money in adopting a new technology that will probably have higher incentives. A risk-averse farmer is not willing to risk current profits in a new technology that costs money, in the hope of higher incentives. To estimate the influence of attitude towards risk on technology adoption, two dummy variables are used by choosing one of the categories (risk-seeking) as a control (or base) category (Table 3.1).

Table 3.1: **RISK DUMMY VARIABLES**

Variables	Risk-seeking	Risk-neutral	Risk-averse
Risk d1	0	1	0
Risk d2	0	0	1

❑ Access to credit

The nature of livestock production systems are not as capital intensive as crop production systems, which makes the availability of credit to buy veterinary technologies as less important than crop technologies, especially in the case of medication technologies where the medication to be purchased is not so capital intensive. However, if the farmer wants to purchase registered or graded rams, access to credit can play a more important role. This variable is included as a categorical variable and it will be considered as one if credit is available and zero if otherwise. It is hypothesised that this variable, which is in general terms an important variable within livestock veterinary technologies, will not emerge as a significant predictor.

❑ Financial management

Financial management was included by the panel as variable. The level of financial management was used as measurement. Olivier (1998) found in unpublished field studies that the farmers adopting medication technologies tend to have better financial management skills. If a farmer keeps any cost and income records this variable was considered as a one and a zero if otherwise.

❑ Traditional medication or remedies used (herbs and plants)

If enough cases emerge from the surveyed data this variable will be used to determine whether the use of traditional medication encourages the adoption of livestock veterinary technologies or not. This variable will have a one if the farmer is using traditional medication and a zero if otherwise.

❑ Training sources on medication usage

The medication technology transfer programmes before 1994 were in the form of training (learning by doing) and demonstration programmes, which is an efficient method suggested by Nagy, Sanders and Ohm (1988) for technology transfer.

In order to limit the categorical explanatory variables (17 different sources were listed in the questionnaire - Annexure A, section F.2), some of the sources had to be classified and grouped in a logical way. The relative low number of cases in some of the categories of adoption makes this action necessary. The farmers were categorised in related groups according to the nature of the sources of training and information. If a group has a zero or low frequency (number of cases), it can be combined with the group that has the closest characteristics. This variable is divided into the following four main groups:

- ***Group 1:*** Self (no-one or do not know where to get training).
- ***Group 2:*** Media (books, television, extension publications and press).
- ***Group 3:*** Co-farmers (co-farmers and sheering association chairperson).
- ***Group 4:*** Extension sources (extension personnel from the Department of Agriculture, cooperative, bank, supplier of inputs, market agents, veterinary surgeon and livestock inspectors).

Group 1 is where the farmer relies on his/her own knowledge and has no access to any of the other three sources of training. Group 2 uses the media. All the sources listed can be linked to the media. Group 3 refers to people approached within the farming community, and group 4 refers to extension officers and people approached with recognised farming knowledge. The way in which this variable is set as dummy variable is presented in Table 3.2.

Table 3.2: **DUMMY VARIABLES FOR TECHNICAL AND FINANCIAL DECISIONS AND TRAINING SOURCES**

Variables*	Self	Media	Co-farmers	Extension officers
Tech d1, Fin d1 & Tr1	0	1	0	0
Tech d2, Fin d2 & Tr2	0	0	1	0
Tech d3, Fin d3 & Tr3	0	0	0	1

* Tech = Technical decisions.
Fin = Financial decisions.
Tr = Obtain training sources on medication usage.

❑ Information sources

Sources of information approached to make technical, financial, and marketing decisions and obtain training when it is needed, are classified in this section and grouped in the same way as described in the previous variable (training sources). When the number of cases in a specific group is too low for the analysis, the groups are combined (Table 3.3). The organising of the dummy variables in this section is given in Table 3.3.

Table 3.3: **DUMMY VARIABLES FOR TECHNICAL AND FINANCIAL DECISIONS**

Variables	Self and media	Co-farmers	Extension officers
Tech d2 & Fin d2	0	1	0
Tech d3 & Fin d3	0	0	1

Because of the low number of farmers using their own knowledge (self) and the media, these two groups were merged in one category (Table 3.3). This action is necessary when quasi-complete separation occurs.

❑ Mating seasons

The usage of mating seasons is an indication of the level of development of the farmers. Breeding technology transfer programmes were one of the main livestock developing programmes of the government before 1994. The use of breeding seasons requires at least basic infrastructure to keep the rams separated from the ewes for some time between breeding seasons. If a farmer adopts such an advanced technology, it is hypothesised that basic medication technologies such as internal and external parasite control would also have been adopted first. For these reasons this variable was selected by the panel of livestock experts to be included in the adoption models. The dummy variable takes the value one if any mating season is used and a zero if otherwise.

❑ Breeding technology

It is hypothesised that farmers using registered and grade rams will most likely adopt livestock veterinary technologies. Farmers will most probably take better care of these animals because of their higher value, and it is therefore hypothesised that they would more likely adopt veterinary technologies to prevent their animals from getting sick or die. The dummy variable takes the value one if registered or grade rams are used for breeding and a zero if otherwise.

❑ Infrastructure

The following types of infrastructures are tested individually for their contribution to livestock veterinary technology adoption:

- Telephone.
- Electricity.
- Roads.
- Transport.
- Local markets.
- National markets.
- International markets.

The dummy variables take the value one if the specific infrastructure is available and accessible to the farmer and a zero if otherwise.

❑ Institutions

In this study institutions were divided into two groups, which were used individually as variables:

- *Group 1*: Government extension system, cooperative extension system and agricultural research.

- *Group 2:* Suppliers of inputs, that is **input suppliers** (businesses where farmers can buy feed and medication for livestock), **output markets** (institutions like the cooperative where wool and mohair and auction pen where livestock can be marketed) and **banking services**.

The dummy variables take the value one if the specific institution is available and accessible and a zero if otherwise.

3.3 THE SURVEY

3.3.1 The study area

The study was conducted in the area of Witsieshoek and the portion of the Harrismith district of Qwaqwa (Old Qwaqwa) and part of the Harrismith/Bethlehem district consolidation of the South African Development Trust (SADT) (New Qwaqwa). Qwaqwa is situated in the south-eastern corner of the Free State province, bordered by Kwa-Zulu/Natal and the Kingdom of Lesotho and situated between 28 and 30 degrees longitude and 28 and 30 degrees latitude (see the orientation map of Qwaqwa in Figure 1.1). It is situated between the Gauteng, Durban/Pinetown and Bloemfontein metropolitan areas.

The Qwaqwa area was chosen for this study because its agricultural activities are mainly on livestock production, and perhaps one of the most active in agricultural technology diffusion programmes up to 1994. The discontinuation of these programmes was due to a population explosion, intense urbanisation and expansion of informal settlements, which forced the farmers away from the service centres to the mountainous areas with low nutritional grazing. This has resulted in a complex situation regarding the conditions for adoption and usage of new livestock veterinary technologies essential for profitable livestock production.

3.3.2 Source of information

Descriptive, theoretical and analytical data and the experience of informed veterinary surgeons are methods and techniques used in this study. Time series data on the population growth, farming area available (hectare) and animal population (small stock units), were attained from the Central Statistical Services (South Africa, Republic, 1991) and surveys done in Qwaqwa by the Development Bank of Southern Africa (DBSA, Sec.2, 1985), the South African Development Trust Corporation Limited (SADTC, 1988), Urban-Econ (1992) and Vrey and Smith (1980) (see Chapter 4).

The collection of farm level information to obtain data and to determine variables (predictors) contributing to the adoption of livestock veterinary technologies was based on the adoption-diffusion theory and previous empirical work. The literature on diffusion (transfer) and adoption of agricultural technologies suggest that the farmer's adoption behaviour is explained by farmer and household characteristics (Wheeler & Ortmann, 1990), its perceptions regarding agricultural technology (Feder *et al.*, 1985) and institutions and the available infrastructure (Hayami & Ruttan, 1985). Taking these aspects into consideration, a questionnaire was developed and farmers interviewed to obtain the relevant information. Only farm level cross sectional data was used in the modelling of the five groups of livestock veterinary technology adoption (veterinary surgeon services and four medication groups).

3.3.3 The development of the questionnaire

A questionnaire (Annexure A) was developed to obtain relevant information on farmer and household characteristics, management, productive parameters, usage of livestock technology, availability and accessibility of institutions and infrastructure. Examples of other questionnaires (Nichola, 1994; Van Schalkwyk, 1997; Venter & Madolo, 1997) and significant variables contributing to technology adoption from other studies in developing agriculture and technology adoption, were used as guidelines.

Discussions with veterinarians and extension officers formerly involved in technology diffusion programmes in Qwaqwa, livestock experts, business economists, computer

experts, bio-statisticians and business psychologists from the University of the Orange Free State were also involved in the development of the questionnaire in order to obtain realistic information for statistical data processing. The questionnaire was pre-tested on six black farm managers in the Bloemfontein area as well as five small ruminant farmers and four extension officers from Qwaqwa, before being used in the survey.

3.3.4 Determination of the farmer population and sampling

Information on the farmer population in New Qwaqwa was obtained from Sentraal Oos Corporate Limited (SOK) where accurate and up to date information was available. From a total of 94 farmers, 78 are small ruminant farmers. No official information on the small ruminant farmer population of Old Qwaqwa is available. After a three-day visit to the area and the collaboration of local extension officers and chair persons of the sheering association from Old Qwaqwa, a list of 178 farmers was compiled from information gathered at sheering sheds (sheering data) and individual farmers visited and found while driving through the mountains.

A proportional stratified sample of 45 small ruminant farmers from a population of 78 in New Qwaqwa and 65 small ruminant farmers from a population of 178 in Old Qwaqwa, were selected.

3.3.5 Data collection

Interviews were conducted by means of a questionnaire with 99 small ruminant farmers in Qwaqwa (63 in Old Qwaqwa and 36 in New Qwaqwa), during the first two weeks of January 1998. Approximately half of the New Qwaqwa farmers were interviewed during a meeting organised by the extension officers from the SOK and the rest of the farmers were visited individually on their farms. The majority of the farmers in Old Qwaqwa were interviewed at sheering sheds, schools and extension officer ward offices and only a few visited individually at their farms. The interviews with farmers who are not fluent in English or Afrikaans was done with the help of translators in order to preserve the accuracy of the information.

3.4 DATA PROCESSING

The SAS (1990) statistical package will be used for data processing in order to define farmer characteristics, possible predictors and to identify the predictors of the defined dependent variables in the different adoption models considered.

In order to prevent the inclusion of two or more highly correlated explanatory variables in the same function that may lead to biased results, the explanatory variables were tested to identify possible correlations between them. The continuous variables were tested using the Spearman Correlation Test and the categorical variables by means of the Kappa Coefficient Test-chance corrected measure of agreement. None of the variables showed correlations either amongst the continuous variables or the categorical variables.

3.4.1 Determination of adoption predictors - modelling

The purpose of this section is to present the methodology used to identify possible predictors to be included in the different models of adoption, the modelling process and the determination of the significant predictors contributing to the adoption of the different livestock veterinary technologies studied (veterinary surgeon services and medication).

3.3.1.1 Determination of possible predictors

The explanatory variables selected from the literature and by the panel of livestock experts were tested for significant differences (to identify possible predictors to be included into the models) between the different adoption groups/categories considered, using one of the following four statistical tests (depending on their type and distribution) described by Siegel (1956):

- The **t-test** will be used to determine significant differences between two continuous explanatory variables with a normal distribution.

- The **Mann-Whitney U-test** will be used to determine significant differences between two continuous explanatory variables with skew distribution.
- The **Chi-square test** will be used in the analysis of categorical explanatory variables with larger frequencies (observations).
- The **Fisher exact probability test** will be used in the analysis of categorical explanatory variables with small frequencies (observations) or where data have low expected scores or counts (values) and to determine significant differences between two categorical explanatory variables.

The age of the farmers is the only variable that had a normal distribution, and therefore the mean will be used as a summary statistic. All the other variables had skew distributions, which make it necessary to use the median in these cases since it is a more representative criterion in a data set where the distribution is skew (Steyn, Smit & Du Toit, 1994).

The explanatory variables of adoption of veterinary surgeon services were divided into two sections, namely continuous and categorical explanatory variables. Two tests were used to determine the differences between the groups for each of the 13 continuous explanatory variables, namely the t-test in the case of normally distributed variables and the Mann-Whitney test for the variables with skew distributions. To determine the difference between the groups for each of the 10 categorical explanatory variables, the Chi-square or Fisher's exact tests were used.

Variables tested, which presented p-values of $\leq 0,15$ between the different adoption categories or groups, were selected as possible predictors and included in the modelling analysis.

3.4.1.2 Determination of significant predictors

The identified possible predictors for each adoption model will be included in the most adequate discrete choice model. The logit and the multinomial logit models are used in this study to determine the predictors contributing to the different adoption categories of livestock veterinary technologies.

These models were selected due to the fact that the dependent variables (adoption categories) considered in this study were measured in a qualitative way as categorical variables (values 0, 1 and/or 2), and not quantitatively, as percentage of adoption (continuous variables). For this reason, the tobit and the double hurdle models, which are more suited to quantitative data, could not be used. Discriminant analysis was also not used in this study mainly due to the fact that it handles linear functions and the technology adoption curve tends to be a sigmoid curve, which is better handled by the logit, the probit and the multinomial logit models. The discrete choice models used in this study are presented and discussed in full in Annexure B. In the same annexure, the mathematical functions (logit models) used to estimate dependent variables with two dummy categories are given in Equations B.6 and B.7, and those used to estimate dependent variables with three dummy categories (multinomial logit models) are given in equations B.8 and B.9. In these models, stepwise regression analysis will be used to identify the predictors contributing significantly ($p \leq 0.15$) to the adoption of livestock veterinary technologies. The outcome of the surveyed data will determine the number of dummy categories to be accounted for in the four medication groups. This will help to decide whether logit models or multinomial logit models will be used.

For the above-mentioned reasons, logit models will be fitted to determine the predictors contributing to the adoption of veterinary surgeon services, as two definitions (conventional and adapted) are under discussion, each with two adoption categories.

Chapter 4

BACKGROUND OF THE STUDY AREA

4.1 INTRODUCTION

In order to understand the factors and circumstances that determine the decision to adopt a new technology, it is important to get a general and integrated overview of the area in which the dependent and the explanatory variables are tested. Both Old and New Qwaqwa are mainly livestock producing areas. To ensure a sustainable livestock production system, the use of veterinary surgeon services and a correct use of medication technologies are essential to the small ruminant farmer (Naude, 1998). The non-adoption of medication technologies usually results in poor reproduction levels and high mortality rates (Schwalbach, 1998). It is therefore important to take a look at the natural resources available to the small ruminant farmers and to evaluate the effect of the quality of these resources on herd health.

The intention with this chapter is to give a short historical as well as a geographical background on Qwaqwa. This will be followed by a brief discussion of the land tenure systems, as well as an overview of the agricultural potential, infrastructure and level of institutions in Qwaqwa. In the forth section the diffusion programmes used in the past with regard to the transfer of small ruminant veterinary and medication technologies will be discussed.

4.2 HISTORICAL BACKGROUND OF QWAQWA

According to the Development Bank of Southern Africa (DBSA, 1985) Old Qwaqwa was previously known as Witsieshoek and Basuto-Barborwa and was occupied by two tribes, namely the Bakwena Tribe (1867) and the Batlokwa Tribe (1873). It is the smallest former homeland of South Africa in terms of land area and *de facto* population and is presently the home of the Basuto.

According to Ashton (1955), the Basuto (Southern Sotho) are not agriculturists by tradition. However, livestock farming forms an integral part of their cultural, ceremonial and religious occasions. Small ruminants are also used extensively in ceremonial occasions and in certain religious rites. Sheep are used for celebrations and black sheep and goats in cases of sickness and sorcery.

It is important to look at the political development of Old Qwaqwa in order to understand and follow the circumstances under which the farmer in Old Qwaqwa is farming. They went through different stages of government policies, which had a direct effect on agricultural development as well as the diffusion and adoption of new technologies.

The first stage of self-government was attained in October 1971 with the establishment of the Basuto-Qwaqwa Legislative Assembly. On 1 November 1974 it became the seventh self-governing state in South Africa. During the general elections of 1975 and 1980 Mr Kenneth Mopeli of the Dikwankwetla Party was elected Chief Minister (DBSA, 1985).

Political development in Old Qwaqwa bears the hallmark of Western-orientated government institutions. Before South Africa became a Union in 1910, political development was mainly of traditional nature. The period subsequent to 1910 involved reconciliation between the traditional and Western-orientated cultures, which in turn led to political development in a Western style. Legislation, however, provided for the retention of traditional tribal authorities, according to which every chief retained his autonomous authority and status (DBSA, 1985). Presently the legislation is a mixture of a Western-orientated government form as well as a traditional political system in the sense that the agricultural land use system is a communal tenure system.

Rapid progress was made during the past four decades in terms of constitutional development, with the result that in 1971 Old Qwaqwa became a government with legislative and executive powers. After the General Election in 1994, Old and New Qwaqwa again became part of the Free State province under the legislative powers of the Free State provincial government (Rautenbach & Malherbe, 1994).

Witsieshoek, an area of 50 172 ha, is described as Old Qwaqwa (DBSA, Sec.2, 1985; Vrey & Smith, 1980). New Qwaqwa, an area of 15 342 ha, is the Harrismith portion which became part of Qwaqwa in 1984 and includes 115 farms in the Bethlehem/Harrismith district (see Figure 1.1). The New Qwaqwa farmers started farming in 1991. This area was consolidated and bought from white commercial farmers in 1984 and 1988 by the South African Development Trust. The last section extends over 80 000 ha of which 21 000 ha has been developed as the Qwaqwa National Park. The rest (59 000 ha) was used to settle 115 farmers from 1991 to 1994 (Urban-Econ, 1992).

4.3 LAND TENURE

The farmers in the sample had two basic land tenure systems, namely communal land and farms on commercial land, which are rented from the government with the option to buy after five years.

4.3.1 Old Qwaqwa

All the farmers in the Old Qwaqwa area are farming on communal land that belongs to different chiefs or headmen. Only people who are residents of the village under the command of the chief can farm in the village area. Farmers can have as many animals as they wish and do not pay an annual rent to the chief or headman for the animals kept on the veld. They only pay R20,00 per animal as registration to the chief or head man (Maloi, 1998).

4.3.2 New Qwaqwa

Between 1991 and 1994 the farmers in New Qwaqwa were settled on consolidated land on the basis that they must pay a yearly rent, which is much lower than the current going rate in the area. They were further settled on the land with the provision that, after five years, they could have the first option to buy the land from the South African Development Trust Corporation Limited (SADTC) (Urban-Econ, 1992). Two of the 36 New Qwaqwa farmers in the sample have already bought their farms and the other 34 are in the process of buying their farms.

The main difference between the two land tenure systems is that the farmers in New Qwaqwa are working towards a goal to buy the farms they are farming on a commercial farming system. The farmers in Old Qwaqwa (communal farming system) know they will never be able to buy the land. The farmers in New Qwaqwa are controlling the livestock numbers to protect the quality of their natural veld (Van der Westhuizen, 1998). These farms also have more and better quality arable land (SADTC, 1988). The geography of New Qwaqwa makes farming easier. The average farm or herd size will most probably be higher than that of the farmers in Old Qwaqwa.

Farmers in New Qwaqwa are farming on land that had been fairly well managed until the late 1980's, while farmers in Old Qwaqwa farm on veld that had been overgrazed over a long period[1].

4.4 GEOGRAPHY

The external environment has a direct influence on the performance of the farming community as well as the diffusion and adoption of agricultural technologies. The landscape and geography, especially the population growth and the effect thereof on the agricultural natural resources, play an important role in the sustainable development of agriculture as well as the diffusion and adoption of livestock technologies in Old Qwaqwa. Approximately 70 per cent of Old Qwaqwa are surrounded by mountains with low nutritional veld (DBSA, 1985).

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[1] Vrey and Smith (1980) has reported a livestock load of 4,8 small stock units (SSU's) per hectare in 1980 in comparison with the official carrying capacity of 1,5 SSU's per hectare.

Census data available on Qwaqwa include only the Witsieshoek area (Old Qwaqwa) up to 1991. In the 1996 census New Qwaqwa was included in the data on Qwaqwa for the first time. The details of this census are not yet officially available. The area data and discussion that follow are applicable on Old and New Qwaqwa as indicated.

Old Qwaqwa has a mountainous nature and a high livestock and human population intensity, which increases every month. Only a relatively small part of this area comprises land available[2] for farming purposes. Although it appears as if a large part of the district consists of grazing land, it is of minor use for agricultural purposes since a large part is either steep mountainous terrain or small units between houses and settlements in villages and informal settlement areas (DBSA, Sec. 2, 1985). According to Fényes (1982) the communal tenure system encourages the build up of animal herds, which makes it very difficult to control livestock numbers and leads to overgrazing. Deterioration (over-grazing) of the natural veld can have a negative effect on the reproduction levels of livestock as well as their medication needs (Katunguka-Rwakishaya, 1994; Ndamukong, Mbomi & Killanga, 1992).

New Qwaqwa has much less mountains and some of the land can be used for crop and fruit production. Livestock numbers are better controlled on these farms owing to a different tenure system and these farmers know the carrying capacity of their farms (SADTC, 1988).

4.4.1 Population

It is important to take population growth into account when policies are formulated for the transfer and adoption of agricultural technologies, because it puts pressure on the economic development as well as the natural resources important for farming. According to Van Rooyen (1982) an area such as Old Qwaqwa is especially vulnerable to this threat as most households in the villages and informal settlements who are not farmers, normally have one or two cattle and a few small ruminants in the urban areas and fodder must be

[2] Approximately 12 000 of the 50 172 hectare is available for farming purposes, of which a large part is mountain veld.

found from somewhere. Squatting (informal settlements) and expansion of houses (urbanisation) on agricultural land normally results in the reduction and deterioration of natural agricultural resources.

The population density differs drastically between Old and New Qwaqwa. Old Qwaqwa has the city of Phuthaditjhaba as well as 16 towns or villages; whereas there are no towns or villages in New Qwaqwa. Some of the 94 farmers who settled in New Qwaqwa do not even stay on their farms, but travel daily to Old Qwaqwa where they live (Van der Westhuizen, 1998). The *de facto* population figures for Old Qwaqwa are presented in Table 4.1. Urban-Econ (1992) gives a population of 470 000 for 1990, while unofficial estimations are that the current population numbers of Old Qwaqwa are between 700 000 and one million people. Migrant workers are not reflected in these numbers.

Table 4.1: **POPULATION AND POPULATION GROWTH OF OLD QWAQWA FROM 1911 TO 1996**

Year	Population	Average growth rate per year (%)
1911[1]	4 882	
1921[1]	4 644	–0,50
1936[1]	7 879	3,59
1946[1]	7 764	–0,15
1951[1]	6 457	–3,62
1960[1]	11 189	6,30
1970[1]	30 225	10,45
1974[1]	80 400	27,71
1980[2]	163 758	12,59
1985[3]	184 524	2,42
1991[3]	351 936	11,36
1996[4]	416 386	3,42
Average growth over 87 years		5,24

1. Coetzee (1980).
2. Van Rooyen (1982).
3. Central Statistical Services (1985, 1991).
4. Calitz (1998).

It appears that the total *de facto* population increased by an average of 5,24 per cent per year, or increased 85 times over the past 85 years; 6,46 per cent per year over the last eleven years and 3,42 per cent per year over the last five years. If this trend continues, the relatively high livestock population (see Table 4.2) will face increasing nutritional problems, on an overgrazed pasture. This may have a detrimental effect on livestock production, but fortunately, at this stage, medication technologies may be able to improve livestock production.

A factor that had the largest effect in this regard was Old Qwaqwa's political and constitutional development, which, between 1970 and 1980, resulted in large-scale settlement of Basuto in the new self-governing state.

4.4.2 Rainfall

Qwaqwa lies within the summer rainfall region of South Africa with more than 85 per cent of the total annual precipitation occurring in the period between September and March. The highest precipitation (1 300 to 2 000 mm per year) occurs in the mountains with a gradual decrease (700 to 800 mm per year) towards the lower lying areas. Approximately 85 per cent of the rainfall occurs in the period September to March (DBSA, Sec. 2, 1985; Vrey & Smith, 1980:48). The rainfall in New Qwaqwa varies between 650 and 710 mm per year (SADTC, 1988).

4.4.3 Evaporation

Information on evaporation is only available for the lower lying area which is 1 750 mm per year. According to this, these areas can be classified as semi-arid (see Chapter 1, Table 1.1). If one assumes that the evaporation in the mountains is less than 1 500 mm per year, the mountains can be classified as sub-humid (Gouws *et al.*, 1987; Unesco, 1977; Vrey & Smith, 1980). No evaporation data are available for the New Qwaqwa.

4.4.4 Temperature

The average daily temperature in Old and New Qwaqwa varies from 6°C in mid-winter to 19°C in mid-summer. Temperatures are very variable and may drop suddenly by up to 10°C. For an average of 70 nights per year the temperature is below 0°C, and the period during which the area gets frost is approximately 150 days per year (DBSA, Sec. 2, 1985; Gouws *et al.*, 1987; SADTC, 1988). This variation in temperatures is even worse in the mountainous areas where most of the small ruminant farmers keep their herds. Snowfalls during late July normally claim the lives of many animals. Some farmers have lost a large portion and in some cases even their total herds during the heavy snowfall of early July 1996 due to a lack of farming infrastructure such as fences and shelter during these cold blisters.

4.5 AGRICULTURAL POTENTIAL, INFRASTRUCTURE AND INSTITUTIONS

A brief outline of the agricultural potential, disease prevalence, external and internal infrastructure and institutions are needed to follow the obstacles farmers are facing in Qwaqwa regarding medication technology diffusion and adoption. The aspects that will be discussed have a direct influence on the approach needed to encourage farmers to adopt medication technologies in order to improve their management and consequently the production levels of their small ruminant herds.

4.5.1 Agricultural potential

Health starts with good nutrition. That is why the availability and quality of natural veld plays an important role in the usage of medication technologies. An animal that is in a good nutritional condition and well fed is normally more tolerant towards parasites and other diseases and can survive cold spells easier than a weaker animal (Schwalbach, 1998). It is therefore important to look at the grazing potential of Qwaqwa as well as the actual situation regarding animal numbers (total SSU's) and population numbers. Escalation of human population numbers reduces the area of natural veld available for livestock

production. The fast growth of the population of Old Qwaqwa and the accompanying urbanisation and expansion of townships (housing) on the lower lying land, which also has a higher grazing capacity, forced the farmers to move their animals away to the mountainous areas where the grazing capacity and quality of grass is lower and cold spells more severe. The higher livestock population density associated to a lower quantity and quality of the pastures increases the risk of diseases. Under these circumstances the adoption and correct usage of new medication technologies become more important.

According to the DBSA (Sec. 2, 1985), the natural veld of Old Qwaqwa can be classified as Hoëberg Sourveld and can be divided into three subsidised-types with different dry matter production levels that influence the grazing capacity of the natural veld. These subsidised-types are Eragrostis-Microchloa veld (400 kg dry matter per hectare per year), Eragrostis-Hetropogon-Microchloa veld (830 kg dry matter per hectare per year) and Themeda-Eragrostis-Hetropogon veld (800 kg dry matter per hectare per year).

In 1974 a total of 41 278 ha natural veld in Old Qwaqwa was available to livestock farmers with an average carrying capacity of 1,5 SSU's per hectare or 61 917 SSU's. The total livestock numbers in 1975 were 111 498 SSU's, with a stocking rate of 2,7 SSU's per hectare (Vrey & Smith, 1980). Table 4.2 gives the SSU's, natural veld available for livestock farming and population numbers to show the problem Old Qwaqwa is facing with the fast increasing population numbers and consequent decreasing of natural veld resources. Because of the the population growth and the high stocking rate of animals of 7,7 SSU's per hectare which are more than five times the carrying capacity, farmers are forced to move with their herds from the low lying areas with high nutritional veld to the mountains where the nutritional value of the veld is consequently lower. A few authors (Fényes, 1982; Vink, 1986) have referred to the tendency of overgrazing of the communal veld which is also a common perception due to the almost free availability of the veld and no one to control the numbers.

Table 4.2: **POPULATION, HECTARE OF VELD AVAILABLE, SMALL STOCK UNITS AND LIVESTOCK NUMBERS IN OLD QWAQWA FROM 1961 TO 1998**

	1960[1]	1961[1]	1974[1]	1975[1]	1981[2]	1982[2]	1983[2]	1996[3]	1998[4]
Population	11 189	N/A	80 400	N/A	N/A	N/A	N/A	416 386	N/A
Cattle	N/A	6 630	N/A	13 178	14 154	13 178	14 463	N/A	11 126
Sheep	N/A	4 163	N/A	5 735	N/A	N/A	N/A	N/A	12 766
Goats	N/A	8 225	N/A	13 910	N/A	N/A	N/A	N/A	11 436
Sheep & goats	N/A	12 388	N/A	19 645	12 545	11 053	11 827	N/A	24 202
Horses, donkeys & mules	N/A	1 753	N/A	2 557	452	373	384	N/A	319
Total SSU's	N/A	60 933	N/A	111 498	99 729	91 986	100 525	N/A	92 553
Hectare available for agriculture	N/A	N/A	41 278	N/A	N/A	N/A	N/A	N/A	12 000
SSU's per hectare	N/A	N/A	2,7	N/A	N/A	N/A	N/A	N/A	7,7

1. Vrey & Smith (1980).
2. DBSA (1985).
3. Calitz (1998).
4. Estimation by the Department of Agriculture, Bethlehem (1998).
   N/A = Not available.

The carrying capacity of the natural veld of New Qwaqwa is 0,885 SSU's per hectare. The tendency of overgrazing does not exist in New Qwaqwa due to the commercially orientated attitude of these farmers (Van der Westhuizen, 1998). Each farmer has his/her own farm and can control the numbers according to the natural vegetation available and feed planted. The population growth is restricted because of the fact that there are no towns, villages and informal settlements in New Qwaqwa. The population is further restricted to the farmers and their permanent labour force, which is much lower than that of the white commercial farmers as the farmer tend to make more use of family labour (Nell, Viljoen & Lyne, 1997).

It is interesting to note that the total number of SSU's has remained relatively constant, but that the area available for grazing has decreased. The area for agricultural purposes decreased from 41 278 ha in 1974 to approximately 12 000 ha in 1998, resulting in more nutritional stress and animals becoming more susceptible to diseases (Naude, 1998). This

aspect will have to be attended to, otherwise the agriculture, and especially livestock production and productivity in Old Qwaqwa, will die slowly. The total livestock numbers in New Qwaqwa were 29 188 SSU's on 74 342 ha available in 1998, or 0,4 SSU's per hectare, which is a much lower grazing pressure than that of Old Qwaqwa.

4.5.2 External agricultural infrastructure

The external agricultural infrastructure in the Old and New Qwaqwa is very poor. Roads vary from poor to non-existent and only three of the 99 farmers in the sample have electricity, whilst only 10 farmers have a telephone and the nearest livestock public auction kraal is at Kestell, which is between 20 and 80 kilometres from the farms. Expensive private transport must therefore be used to convey farmers and animals to auctions, veterinary clinics and the cooperative to buy medication, which has a negative effect on the adoption of these inputs and services. There are no roads in the mountainous areas and here the only means of transport is horses and donkeys. A summary of the results from the survey of the infrastructure is presented in Table 4.3.

Table 4.3: **INFRASTRUCTURE AVAILABLE TO FARMERS**

Infrastructure available to farmers	Total number (n=99)
Roads	44
Transport	13
Telephone	10
Electricity	3
Local markets	55
National markets	3
International markets	0

Source: Survey data (January 1998).

4.5.3 Farm (internal) infrastructure

Livestock infrastructure in Old Qwaqwa, i.e. handling facilities such as dipping-tanks and dipping-pens that were build before 1994, are in most cases vandalised, deficient or non-existing and obsolete (Claassens, 1998). Fencing of the natural veld was done before

1994, but has since also been removed. Except for a few caves in the mountains, there is no shelters available for the small ruminant farmers to protect their stock from thefts and the cold in winter time. The only agricultural infrastructure still used by the small ruminant farmers are the five shearing sheds that are used for shearing woolled sheep and Angora goats. A few community dairies and pigsties are also operational (Claassens, 1998).

The farm infrastructure in the New Qwaqwa, such as fences, sheds on farms, shelters (kraals), livestock handling facilities, water points for the livestock and other operational facilities are in a better condition as these farmers obtained their farms six to seven years ago. The tenure system, in the sense that farmers have an option to buy their farms, has had a positive effect on the maintenance and protection of the facilities (SADTC, 1988). The fact that these farms are relatively far away from Phuthaditjhaba, the urban area of Qwaqwa, also helps to protect the farming facilities against theft.

4.5.4 Institutions

The availability of institutional services to the sample farmers is summarised in Table 4.4. The column "total number of farmers" refers to the number of farmers who indicated that the specific institutional services are available.

Table 4.4: **INSTITUTIONAL SERVICES AVAILABLE TO FARMERS IN QWAQWA**

Institutional services available to farmers	Total number of farmers
Government extension system	37
Cooperative extension system	45
Agricultural research	6
Input suppliers (businesses where farmer can buy seed, fertiliser, fuel, etc.)	22
Output markets (institutions such as the cooperative where output can be marketed)	8
Banking services	13

Source: Survey data (January 1998).

Although these institutions of support exist in the urban area, they are not accessible to the farmers due to distance. The only two cooperatives operating in Qwaqwa are Agri-Mark in Phuthaditjhaba and SOK Limited in Harrismith and Kestell.

4.5.5 Disease prevalence

The pressure to move to a less valuable nutritional area in the mountains with more climatic extremes (cold in winter and humid in summer), as well as an increasing livestock concentration, results in a higher infection pressure of the environment, which in turn leads to a more contaminated environment and more susceptible hosts (animals) (Erasmus, 1998).

From an economical viewpoint, the most important groups of diseases in Old and New Qwaqwa were identified by Naude (1998) as scab (which is the most important external parasite disease); pink eye (the most common infection); blue tongue, black quarter and pulpy kidney (the most common diseases); roundworm, nasal worm and tapeworm (the most common internal parasites). These diseases are limiting the production potential and reproductive levels of small ruminants in the area.

4.5.6 Small ruminant medication sales in Qwaqwa

Official statistics on medication sales or consumption are not available for Qwaqwa. After an in-depth discussion with Venter (1998) and McDonald (1998), it was concluded that an estimation of small ruminant medication sales or consumption for either Old Qwaqwa, New Qwaqwa or Qwaqwa as a whole is impossible. However, Agri-Mark's sale figures for 1998 indicated that external parasite remedies for small ruminants have the highest sales, followed by general medication, internal parasite remedies and lastly vaccination sales.

4.6 METHODS OF SMALL RUMINANT VETERINARY SURGEON SERVICES AND MEDICATION TECHNOLOGY TRANSFER

4.6.1 Medication technologies

The economic and financial incentives or increased returns on a new technology, according to De Boer, Knipscheer and Kartamulia (1992), are perhaps one of the most important motivations for a farmer to adopt and keep on using a new technology. The possible incentives from medication adoption are perhaps one of the most important factors in the small ruminant production process as they allow the prevention and treatment of disease that may cause mortality, loss of weight, slower growth rates or reduce the quality of the products (meat, wool, hides, milk, etc). Medication technology therefore plays a strategic and economic role in small ruminant production.

The five livestock technology transfer programmes (the use of upgraded Angora goat rams, mutton sheep rams, beef cattle bulls, medication and sheering) were in fact implemented in Qwaqwa before 1994. These programmes were handled by two divisions in the Department of Agriculture, namely livestock production and veterinary services. The livestock production division of the Department of Agriculture handled the breeding and the feeding technologies, while the veterinary services division, assisted by the extension division, handled the animal husbandry and the medication (herd health) technology transfer programmes (Naude, 1998).

4.6.2 Medication technology transfer (diffusion) programmes

The Department of Agriculture's division of veterinary services originally initiated the medication technology transfer programme. At first they concentrated on programmes to prevent diseases and reduce mortality.

Another objective of the medication technology transfer programme was to provide the small ruminant farmer with the most important remedies at an affordable price (subsidized up to 80%). Another important part of the technology transfer programme was to help the

farmers to use the correct medication as well as the correct way of application. The only remedies that the farmers did not pay for, were those used by the Department of Agriculture in compulsory vaccination or dipping campaigns to control a national outbreak such as scab. With the help of the Department of Agriculture, the farmers kept the dipping and livestock handling facilities, which were situated at every sheering shed, in good operational order. The rest of the internal and external parasite remedies and vaccinations were subsidised to their cost price and made available at the sheering sheds (Claassens, 1998).

According to Naude (1998) the National Defence Force used to station at least one veterinary surgeon in Old Qwaqwa on a permanent basis during his compulsory military service. These veterinary surgeons played a very important role in the transfer of medication technology to the small ruminant farmers. This action had the result that before 1994 Old Qwaqwa was never without a permanent veterinary surgeon. There were also six animal health officers, and one government veterinary surgeon who assisted in transferring new medication technologies during Qwaqwa. Private veterinary surgeons were also active in Qwaqwa during the same period. The extension officers and animal health officers played a very important role in medication technology transfer in the sense that they assisted the farmers who are illiterate in Afrikaans or English. They were also the link between the small ruminant farmers and the veterinary surgeons.

Two small ruminant specialists and eight extension officers of the Department of Agriculture managed the medication technology transfer programme in collaboration with the animal health officers from the veterinary services division. The main objective of this programme was to stress the importance of regular dipping, dosing for endo-parasites and vaccination programmes. Other therapeutical medication practices were also attended to, with direct impact on the survival of the animals. The small ruminant farmers were informed on the advantages of correct and regular use of the different medication technologies (Claassens, 1998).

The extension ward officers from the Department of Agriculture later became part of the so-called "joint extension team" for the development and transfer of medication

technologies. This programme did not function very effectively due to logistic constraints. The best results were obtained when the area was divided into wards with an animal health officer in each ward directly under control of the veterinary surgeon. This resulted in a closer contact between the veterinary surgeon, animal health officer, extension officer and the farmer. Perhaps the most important action in this transfer process was the demonstrative part (learning by doing) of medication usage (Naude, 1998). Small ruminant farmers formed groups and associations that bought medication in bulk at discount prices.

Most of the technology transfer actions were held at the sheering sheds on farmers' days, which were regularly organised and presented by the different ward extension officers. Specialised people from the Department of Agriculture, veterinary surgeons (private and governmental) and animal health officers were also used to train small ruminant farmers and transfer medication technologies at these service points. The farmers' days were held once a month at the sheering sheds in Old Qwaqwa and every two weeks at different venues in New Qwaqwa. It was easier to get hold of the farmers in New Qwaqwa than in Old Qwaqwa where the farmers are living with their herds in the mountains (Claassens, 1998).

According to Claassens (1988), Agriqwa, a corporation of the Qwaqwa Government, played a major role in small ruminant extension in New Qwaqwa. These farmers were treated like commercial farmers and extension officers held more frequent farmers' days in this area.

After the general election in 1994 the experienced extension officers, the Defence Force veterinary surgeon, government veterinary surgeons and animal health officers were employed in other capacities in Old Qwaqwa, as the Department of Agriculture felt that it was too expensive to continue their services in Qwaqwa (Olivier, 1998). Qualified experienced extension officers and animal health officers were transferred to other areas and replaced by officers who were less experienced and who were not livestock specialists, although they had a national Agricultural Diploma. The result was that the transferring of technology slowed down and in some wards came to a standstill (Olivier, 1998; Naude, 1998). Sheering sheds are mainly run by sheering associations themselves and visits from

extension officers and veterinary people are quite rare (Komako, 1998). The extension officers and small ruminant inspectors still have access to the veterinary surgeons in Bethlehem (some 80 km from Qwaqwa), but this is not enough for these relatively inexperienced extension officers to effectively diffuse and transfer medication technologies to the local farmers.

4.7 CONCLUSIONS

It is clear from the discussions that the resources available, the internal and external infrastructure in Old and New Qwaqwa as well as institutions, are not in place or are not in a well-maintained state to support the efficient diffusion of new technology programmes. The influence of the fast increasing population growth on the deterioration of the natural resources, which are essential for the development of farmers in former homelands, is very serious in Old Qwaqwa but less important in New Qwaqwa. After the 1994 general elections all veterinarians, some of the experienced health officers and some extensionists stationed in Qwaqwa were transferred to other capacities and even other areas of the country. This had a significant slow-down - almost a standstill effect - on the diffusion of livestock technologies to the local small ruminant farmers.

Chapter 5

DESCRIPTION OF SURVEYED DATA

5.1 INTRODUCTION

The characteristics of farmers within the area where the adoption of new technologies are analysed, is important. It is also important to know to what extent the farmers are susceptible to new ideas and technologies and to what extent they were exposed to these technologies before. The external environment (conditions) and resources available to these farmers must be investigated to be included into the diffusion programmes. The flow of information is a further important link in the diffusion process. On the one side is the sender (extension officers, co-farmers, the media, and family) of the message about new technologies and on the other side the farmers who are the recipients of the information (message) on new technologies within the specific characteristics of these farmers and the infrastructure as well as the location (Von Thünen's theory) that will determine the rate and level of adoption.

To understand the total environment in which technologies must be exploited, it is important to analyse the demographic information (human capital endowments), attitude towards risk, availability and accessibility as well as the functioning of extension services, infrastructure and institutions as well as the information on the adoption of small ruminant veterinary technologies. The data described in this chapter is derived from the survey done in Qwaqwa.

5.2 DEMOGRAPHIC INFORMATION OF THE SAMPLE FARMERS

This section describes the characteristics of communal households in Old Qwaqwa, of those renting farms from the South African Development Trust Corporation Limited (SADTC) or owning private farms in New Qwaqwa. The data is described in quantitative and qualitative terms. The discussion of the data is mainly restricted to the explanatory variables influencing the adoption of veterinary technology as identified in Chapter 3.

In this study a small ruminant farmer is defined as any person owning five or more small ruminants (mutton sheep, woolled sheep, Boer goats and Angora goats) for breeding purposes. Only eight per cent of the 99 farmers in the sample were women (widows) who had to take over the farming activities when they lost their husbands. This number is too small to do any statistical analysis and will be treated in the total group of 99 farmers. The fact that most of the farmers are men corresponds with the research done by Norton and Alwang (1993) who found that in many African countries male farmers tend to livestock farming while the women are in charge of food and crop production.

Age is the only variable that had a normal distribution and therefore the mean will be used as summary statistic in this case. All other variables have skew distributions and therefore the median is used to summarise the information in these cases as the median is a more representative criterion than the mean in data sets with skew distributions (Steyn, Smit & Du Toit, 1994). The age of the farmers and the distribution of their family members are shown in Table 5.1.

Table 5.1: **AGE OF FARMERS AND DISTRIBUTION OF FAMILY MEMBERS**

Age (n=99)	Median family members
>54	1
35 - 54	1
15 - 34	2
7 - 14	1
<6 years	0
Total family size	7
Mean age	55

The median family size in the total sample is seven and varies from one to 15 per household. The age of farmers in the sample varies from 19 years to 85 years, with a mean of 55 and a coefficient variation of 26,9 per cent.

5.3 HUMAN CAPITAL ENDOWMENTS

Human capital endowments are made up by different personal characteristics. In this section emphasis is placed on educational qualifications, knowledge which includes literacy and arithmetic abilities, farming experience, and farming efficiency (weaning percentage).

The educational qualifications of the farmers, their spouses and their children are shown in Figure 5.1.

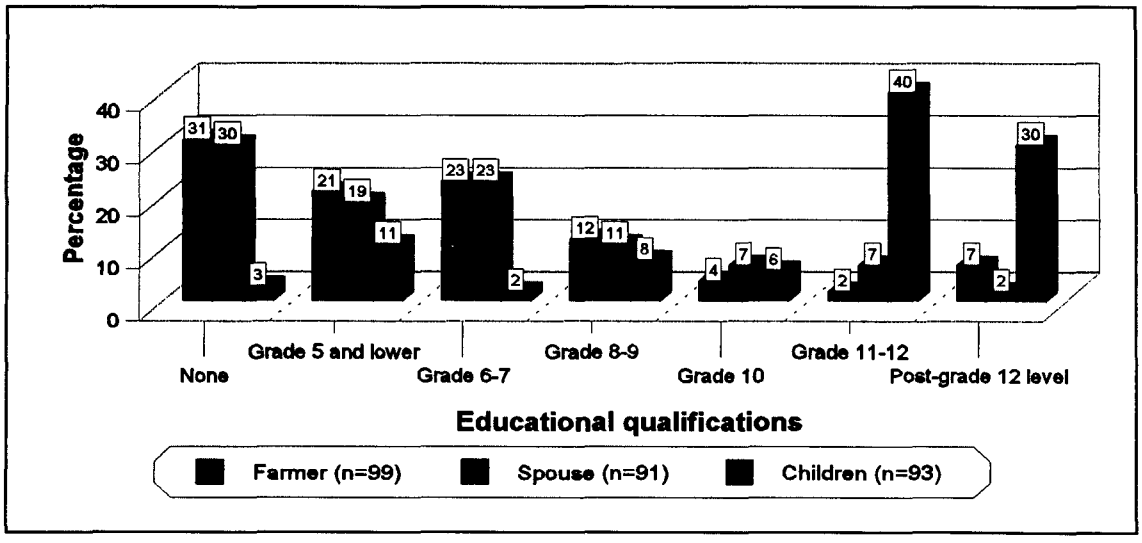

Figure 5.1: **Educational qualifications**

As can be seen in Figure 5.1, the educational level of the farmers and their spouses is much lower than that of their children. The major improvement in educational services and facilities which took place in the period 1980 to 1991 (DBSA, 1985; Central Statistical Services [South Africa, Republic], 1985, 1991a) is the reason why this tendency in the data is observed. The educational level of the farmers, spouses and children vary from no school education to post-grade 12 level. Only seven per cent of

the farmers and two percent of the spouses have a qualification higher than grade 12. Thirty per cent of the farmers have children with qualifications higher than grade 12.

The **literacy skills** were determined by means of direct questions to the farmers regarding their ability to speak, read and/or write English, Afrikaans and Sotho or any other native language. The **arithmetic skills** were measured in terms of none (cannot do any calculations), little (can add and subtract with ease), average (can add, subtract and multiply with ease) and good (can add, subtract, multiply and divide with ease). Two basic skills are necessary because if the farmer cannot read the instructions and is not able to make basic calculations regarding the dosage of the medication, the result can be disastrous in some instances, particularly under deficient extension supervision, as has been the case in Qwaqwa since 1994. The literacy abilities of the farmers in the survey are shown in Figure 5.2.

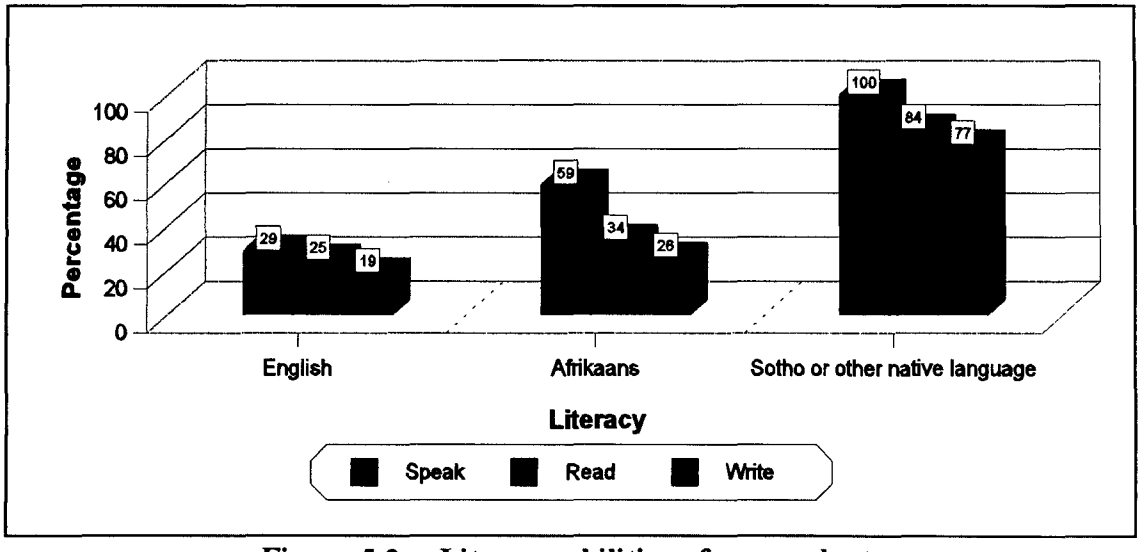

Figure 5.2: **Literacy abilities of respondents**

The results in Figure 5.2 reveal that only 40 per cent of the farmers in the sample have the ability to read English or Afrikaans, whereas 33 per cent of the farmers are literate in English or Afrikaans and have an average or good ability to make basic arithmetic calculations.

Basic arithmetic skills also play an important role in the adoption of medication technology. These results are shown in Figure 5.3.

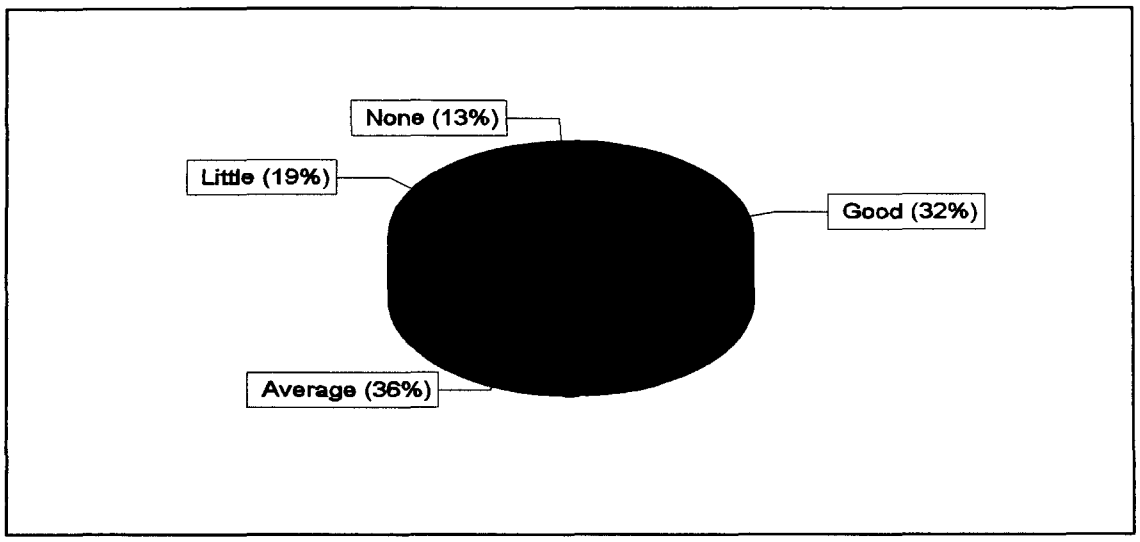

Figure 5.3: **Arithmetic abilities of respondents**

The above figure shows that 36 per cent of the farmers in the sample have an average arithmetic skill and 32 per cent have a good arithmetic skill. The conclusion can be made that if only 33 per cent of the farming population can read the specifications of medication technologies properly and make basic calculations on the dosage of medication, transfer of medication technologies by means of extension officers or other additional help in this field is important.

Farming experience is presented (proxied) in Figure 5.4.

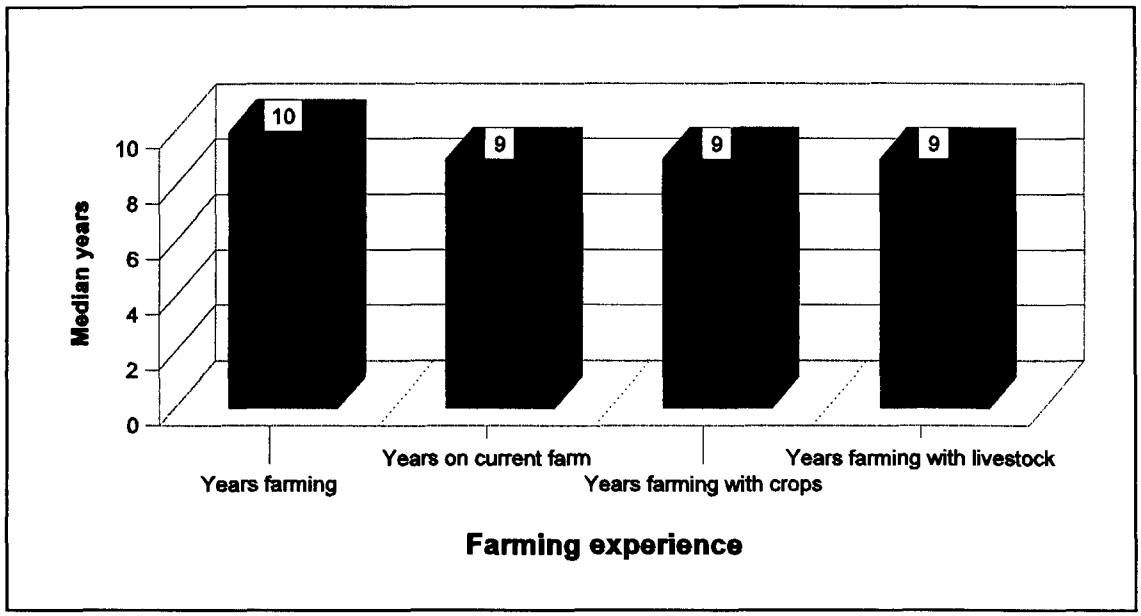

Figure 5.4: **Farming experience of respondents**

Farming experience with livestock varies from one to 55 years and crop production experience from three to 40 years. The median years of farming experience with livestock of nine years, is an indication that the farmers in Qwaqwa have a median of five years exposure (1989 to 1994) of the veterinary technology transfer programmes managed by the government before 1994.

If weaning percentage is an indication of the farming efficiency of the sample group, it is relatively low (Figure 5.5). One of the main reasons for the low weaning percentage of the sample farmers is the lack of proper nutritional management and mating technologies. (A full discussion on mating or breeding technologies will follow later in the chapter.)

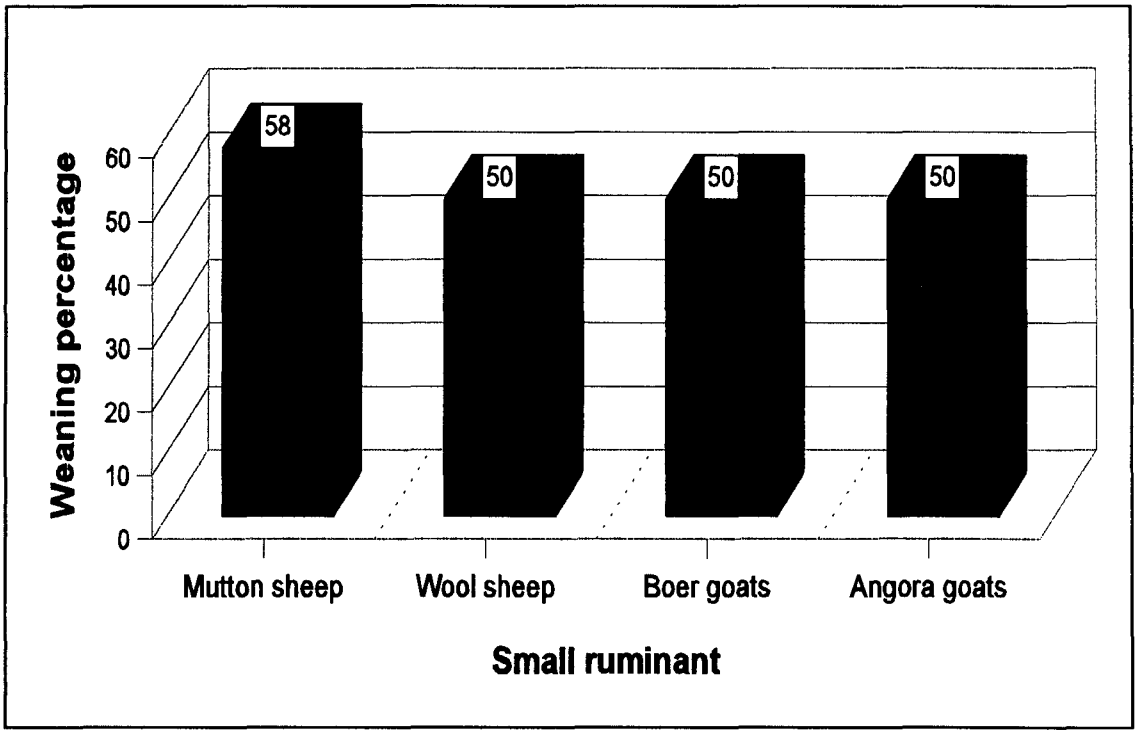

Figure 5.5: **Weaning percentage**

Training is also part of human capital endowments. Farmers were asked to indicate all the sources on the usage of veterinary technologies they approach to obtain training when it is needed. The results are presented in Table 5.2.

Table 5.2: **TRAINING SOURCES APPROACHED BY SAMPLE FARMERS**

Training sources	Percentage
Television	1
Extension publications (all leaflets periodicals)	1
Co-farmers – neighbours	20
Department of Agriculture – Extension officers	36
Cooperative extension officers	24
No one – use own physical or technical records	23
Bank manager	1
Supplier of inputs such as the cooperative manager	6
Market agents	1
Read in the press (news papers, magazines, etc.)	8
Sheering association: chairperson	14
Livestock inspector	3
The media	1
Does not know where to get training	2

Only 36 per cent of the 99 farmers indicated that they approach the Department of Agriculture's extension personnel when they are in need of training. Twenty-five per cent use either their own knowledge or do not know where to get training, 24 per cent approach cooperative extension officers, 20 per cent of the farmers approach co-farmers and 14 per cent approach chairpersons of sheering associations. These results indicate that only about a third of the farmers are using the extension officers of the Department of Agriculture to fulfill their training needs on the usage of medication. The majority of the farmers use other sources of information. About half of the farmers use their own or their neighbour's knowledge for their training needs, which is not only dangerous, but also a sign of the lack of efficiency of the present extension services.

5.4 MANAGEMENT SKILLS AND ENDOWMENTS

Management consists of various fields, namely planning, decision-making, record-keeping (financial, physical and economical), financial management and marketing management. In the first section of Table 5.3, a summary is given of the extent of planning. Financial

strategies which are important for long term success are given in the second section of the same table.

Table 5.3: **EXTENT OF PLANNING AND FINANCIAL STRATEGIES**

Extent of Planning	Percentage
Thorough plans and objectives stated	21
Some plans (rough, incomplete)	30
Only some idea about planning	43
No plans (not considered)	6
Days planned in advance (median days)	122 days
Important financial strategies for long term success	**Median rating***
1. To have sole land rights	4
2. Keep production costs low	2
3. Must get financial management training before I start farming	4
4. My farm must earn a substantial profit for growth	2
5. I must be able to honour my instalments each year	2

* Not important = 1.
Important to not important = 2.
Important = 3.
Important to very important = 4.
Very important = 5.

Forty-three per cent of the farmers indicated that they only have some idea about planning, 30 per cent have some rough and incomplete plans, 21 per cent have thorough plans and set objectives, while six per cent have no plans for the future. The fact that only 21 per cent of the sample farmers have thorough plans is an indication that farmers are quite dependable on extension and veterinary advice in adopting small ruminant medication technologies. It further emphasises the importance of guiding the farmers towards a prophylactic system of medication management of small ruminant herds.

The data further revealed that the median period that farmers planned ahead varies from 0 days to 1 460 days (four years). Ten per cent of the farmers are planning between nil and seven days ahead. Fifteen per cent are planning 30 days ahead; 12 per cent 60 days and 28 per cent 365 days. Fifty-one per cent of the farmers are planning up to 122 days or four months ahead and 89 per cent to a maximum of 365 days or one year. The fact

that approximately a quarter of the farmers are planning a month or less in advance is an indication that it is expected that the adoption of medication technologies for preventative reasons will not be up to standard.

A question was asked on the importance of the financial strategies a farmer must follow or have long term farming success. This was rated from 1 (not important) to 5 (very important). Only one of the statements could score 5, one 4 and so on. These statements are also listed in Table 5.3. On the question, what the farmers think the most important financial strategies are which they must follow in order to ensure a long term success of their farm or farming operation, both sole land rights (65%) and financial management training before they start farming (59%) was given a high priority (important to very important) by the farmers. The rest of the strategies all scored lower priorities.

Decision-making is also an integral part of planning (see Table 5.4). When it comes to technical decisions, in 58 per cent of the cases the farmer is taking this decision on his/her own and the husband and wife together in 17 per cent of the cases. Financial decisions are taken in 44 per cent of the cases by the husband and wife together, 22 per cent by the husband, wife and children and in 21 per cent of the cases by the farmer alone.

Table 5.4: **DECISION-MAKING**

Person making the decisions	Technical* (%)	Financial* (%)
Farmer	58	21
Farmer and wife	17	44
Farmer, wife and children	11	22
Wife	2	3
Father	2	1
Farmers and father	1	1
Manager	1	-
Farmer and manager	1	1
Farmer and son	6	4
Mother and son	-	1
Farmer and mother	1	1

* n = 99

From these results it is possible to generalise that most of the technical decisions are made by the farmer alone, while financial decisions are taken with more involvement of the rest of the closer family (wife and children). The same tendency was observed by Nell, Viljoen and Lyne (1997) in a study in Thaba Nchu amongst the same type of farmers.

Keeping records is perhaps one of the most important barometers of managerial skills. It is very difficult for a farmer to manage a farm without proper farming records. The results of the study regarding financial management are shown in Table 5.5.

Table 5.5: **FINANCIAL MANAGEMENT**

Record-keeping		**Percentage**		
Farmers keeping records		97		
Farmers who think that record-keeping is important		99		
Level of record-keeping		**Median level***	**Percentage (n = 96)**	
			n	%
Cost records		3	96	43
Income records		3	96	43
Production records:	Crops	3	44	34
	Livestock	3	96	42
Labour records		3	94	38
Inventory records		2	91	35
Importance and purpose of records		**Median of importance****	**Percentage (n = 96)**	
Important in determining financial position		3	70	
Important for decision-making and planning		3	57	
To keep the bank or cooperative manager happy		1	52	

* Thorough and neat = 4
Rough and incomplete = 3
Only idea = 2
None = 1

** Not important = 1
Important = 2
Very important = 3

Table 5.5 indicates that income and cost records are thoroughly and neatly kept by 43 per cent of the 96 farmers keeping these kind of records or 42 per cent of all farmers. Crop production records are thoroughly and neatly kept by 34 per cent of the farmers who keep these records and 42 per cent of the farmers keeping livestock production records, are keeping them thoroughly and neatly. Labour records are thoroughly and neatly kept by 38 per cent of the 94 farmers keeping labour records and 35 per cent of the 91 farmers who used an inventory, keep a thorough and neat inventory. It is interesting that one farmer even keeps his records on the wall of the cave he is living in. These results indicate that nearly all farmers (97%) are keeping some or other kind of basic records, but less than half (45%) of the farmers are at least keeping rough and incomplete.

The importance of record-keeping is reflected in the reaction of the farmers to the statements for the reason they want to use the records for (Table 5.5). Seventy per cent of the farmers said that records are very important in determining their financial position, 23 per cent said it is important and only six per cent said that record-keeping is not important. Fifty-seven per cent of the farmers rated the usage of records for decision-making and planning as very important and 36 per cent as important. Fifty-two per cent of the farmers rated the last statement, namely keeping the bank and cooperative managers happy, as not important. The reason for this last result is that only 30 per cent of the farmers are using foreign capital (see Table 5.9).

Marketing management is one of the very important management endowments. If a farmer cannot market his/her livestock production at a profit, the chances of adopting and buying new livestock technologies are low. To a certain extent diversity of marketing channels also indicate the entrepreneurial skills of the farmer. Only 26 per cent of the 99 farmers (10% farmers from Old Qwaqwa and 16% from New Qwaqwa) have markets within accessible distance from their farms (Table 5.6).

Table 5.6: **MARKETING CHANNELS USED BY FARMERS**

Market system/ channel**	Sheep (n=91)		Goats (n=57)		Wool and skins (n=90)		Hair and skins (n=53)	
	n	%*	n	%*	n	%*	n	%*
Auction or public sale	34	56	11	55	2	50	-	-
Open market in town	20	42	7	75	3	50	1	100
Private sale	57	50	42	67	12	100	4	100
Local trader or cooperative	4	100	1	100	74	100	48	100
Own consumption	69	24	36	33	-	-	-	-
Value-adding direct marketing	1	100	-	-	-	-	-	-
Exchange with neighbour	1	100	-	-	-	-	-	-

* Median % of animals or produce marketed through this channel, of those who use this channel.
** Number of farmers within accessible distance from markets: 26.

Only 37 per cent of the sheep farmers are using auctions or public sales as marketing channels for sheep and they are marketing only a median of 56 per cent of their production in this manner (Table 5.7). The other 44 per cent of the production is used for their own consumption. Sixty-three per cent of the sheep farmers sell 50 per cent of their sheep by means of private sale and 76 per cent of the sheep farmers consume 24 per cent of the sheep production themselves.

Seventy-four per cent of the goat farmers sell 67 per cent by means of private sale and 63 per cent consume 33 per cent of the goat production themselves. The high percentage of private sales and own consumption of goats was expected because the Sotho people use goats for religious and cultural purposes (Ashton, 1955).

5.5 ENTREPRENEURIAL INFORMATION

The creative person is the one who will try new technologies before his/her co-farmers do so. A set of statements to measure the attitude and characteristics of the farmers towards the different entrepreneurial indicators, namely leadership, need for achievement of goals,

creative skills, motivation to progress, the need for autonomy and attitude toward risk were constructed with the help of Human (1997) and tested with the help of Komako (1998). The responses to these statements are given in Table 5.7 below.

Table 5.:7 **STATEMENTS TO DETERMINE ENTREPRENEURIAL SKILLS**

Section	Statements (n=99)	Median score*
1	**Leadership**:	
	You are not afraid to try a new technique (pesticide) before your fellow farmers and you will first try to do it on your own before seeking help (self-starter)	3
	Even though people tell you "it can't be done", you have to find it out for yourself	4
2	**Need for achievement of goals**:	
	If you have a problem (challenge) on your farm you will keep on trying to solve the problem (challenge) and you will not quit	4
	You have the ability to organise the four production factors (land, labour, capital and management) in such a way that the goals set for the farm are achieved	3
3	**Creative skills:**	
	You have the ability to adapt to changes in the farming environment	3
	You are always looking for opportunities to increase the profit of your farm	4
4	**Motivation to progress**:	
	You have the urge to achieve the goals set for your farm for the future	4
	You like supporting and helping your fellow farmers when you see they are struggling or when they come to you with problems	4
5	**Need for autonomy**:	
	You do not often need to ask other people's opinions before you decide on important things – you can rely on your own knowledge or family to make good decisions	3
	You are not afraid to be different when it comes to the adoption of new technologies on your farm	3
6	**Attitude towards risk**	
	Variety A will give you a profit of R10 000 in two out of ten years and in the other eight years R0 (High profit, high risk) (3)	2
	Variety B will give you a profit of R3 000 in six out of ten years and in the other four years R0 (Medium profit, medium risk) (2)	
	Variety C will give you a profit of R2 000 in eight out of ten years and in the other two years R0 (Low profit, low risk) (1)	

* Strongly disagree = 1
Disagree = 2
Agree = 3
Strongly agree = 4

Practical examples customary to Qwaqwa were also used to make sure that the best quality answers possible were attained from the farmers. The farmers had to indicate whether they strongly disagree (1), disagree (2), agree (3) and strongly agree (4). Sections 1 to 6 (indicators of entrepreneurial skills) carry the same weight. The score for risk attitude (section 6) was then multiplied by 2,7 to obtain the same weight as the other sections (1-5) also used to determine entrepreneurial skills (Human, 1998; Pretorius, 1998). The lowest possible score is 13, the highest 48 and the average 30,5. The sum of the scores for the questions asked (sections 1-6) (Table 5.7) indicates the level of entrepreneurial skills. The scores in the sample varied from 23 to 47, with a mean and median score of 36. This normal distribution with a mean/median score of 36, higher than the average score possible (30,5), is an indication that the entrepreneurial skills of the farmers tend to be above average according to the questions asked.

5.6 FARM OR HERD SIZE

Due to the fact that Old Qwaqwa has a communal tenure system and New Qwaqwa rented or privately owned farms, herd size instead of farm size were used to measure the size of the farming operation. The size of the farms in New Qwaqwa varied between 161 ha and 1 260 ha, with an average size of 455 ha. These farm sizes were not determined through market forces but were determined by the state on the basis of areas which would give the same Nett Farm Income under the same circumstances.

The herd sizes for the different livestock types are summarised in Table 5.8. The numbers of the different livestock types all have a very skew distribution.

Table 5.8: **HERD SIZES FOR DIFFERENT LIVESTOCK TYPES**

Livestock types	Median numbers
Cattle (n = 91)	18
Mutton sheep (n = 53)	34
Woolled sheep (n = 42)	41
Boer goats (n = 29)	31
Angora goats (n = 43)	42
Pigs (n = 8)	3
Poultry (n = 3)	70
Other (donkeys and horses) (n = 13)	3

5.7 CREDIT-USE (INDEBTEDNESS) AND ACCESS TO CREDIT

Only 16 per cent of the farmers in Old Qwaqwa and 56 per cent of the farmers in New Qwaqwa make use of foreign capital (Table 5.9), but 64 per cent of the farmers in the total sample are in need of credit. Credit is not available to 36 per cent of the farmers, and 39 per cent of them stated that the bank does not want to lend them money due to insufficient security, and 28 per cent stated that they do not have access to credit.

Table 5.9: **USAGE AND ACCESS TO CREDIT**

Usage and access to credit and indebtedness (n=99)	Percentage
Farmers using foreign capital	30
Farmers needing credit	64
Credit available for farmers	64
Credit not available for farmers	36
Reason why credit is not used (n=36)	**Percentage**
Do not need extra money	19
Have no access to credit	28
The cost (interest) of money is too high	19
Bank does not want to lend money due to insufficient security	39
Poor repayment ability of farm	19
Do not know where to get credit	6
Afraid of credit	6
Drought – debt too high	11
Children have to pay debt if farmer dies	3
Source of funding livestock inputs and rams	**Percentage**
Own funds	88
On credit	0
Combination of own and credit	12

Credit granted by the agricultural cooperative (Table 5.10) was exclusively used for crop production loans by New Qwaqwa farmers. From the four loans granted by the Agricultural Bank of South Africa to New Qwaqwa farmers, two were for bonds to purchase two privately owned farms and the other two were for crop production loans. The 10 Agri-Mark loans to New Qwaqwa farmers were mainly used for production loans

(7) and repayment sales agreements (hire purchases) (3). The two commercial bank loans were both awarded to Old Qwaqwa farmers.

Loans from family and friends were mainly used to help pay for school tuition fees of the farmers' children. The number of farmers involved, mean and median interest rates and amounts taken up by the farmers, are summarised in Table 5.10. Of the 30 formal sources, which granted credit to the farmers, 20 are from New Qwaqwa and 10 from Old Qwaqwa. This is an indication that farmers in New Qwaqwa make more use of credit than farmers in Old Qwaqwa. The usage of informal credit sources is very low and needs no further discussion. During the survey most of the farmers indicated that they are afraid of the high interest rates of the informal credit sources, family excluded.

Table 5.10: **INDEBTEDNESS OF FARMERS**

Sources	Median		Mean	
	Interest rate (%)	Amount	Interest rate (%)	Amount
Formal sources:				
Commercial bank (n = 2)	20,00	R12 000	20,00	R33 000
Agricultural cooperative (n = 15)	19,00	R40 000	18,75	R47 706
Agricultural Bank of South Africa (n = 4)	19,00	R80 000	18,75	R92 500
Agri-Mark (n = 10)	19,00	R43 000	15,89	R51 222
Informal sources:				
Credit unions (n = 1)	300,00	0	300,00	0
Credit clubs (n = 0)	-	-	-	-
Family and friends (n = 5)	0	R200	6,00	R1 280
Stokvels (n = 1)	25,00	0	25,00	0

5.8 ATTITUDE TOWARDS RISK

Figure 5.6 summarises the results of the farmers' attitude towards risk. (See also Table 5.7 for the questions asked to determine the attitude towards risk.)

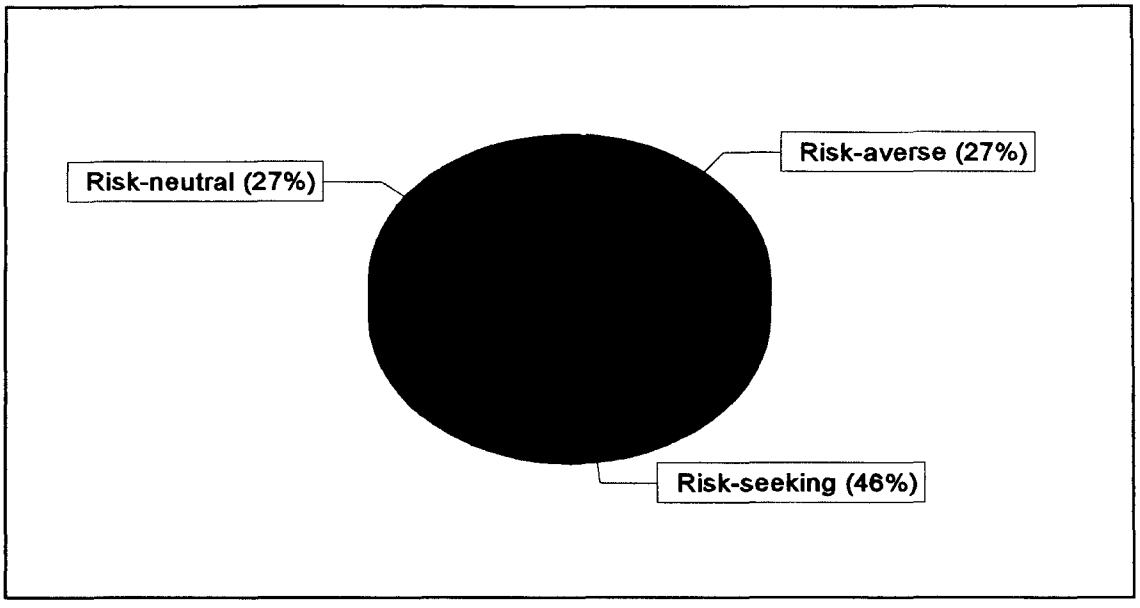

Figure 5.6: **Attitude towards risk**

Twenty-seven per cent of the farmers are risk-averse or prefer a low profit, 27 per cent risk-neutral or medium profit and 46 per cent are risk-seeking or high profit seeking. It is possible to realise from these results that only a minority of the farmers in Qwaqwa are risk-averse, and therefore most of the farmers would be potential adopters of new technologies if it can increase their profits.

5.9 EXTENSION SERVICES

Extension is one of the most important components of technology transfer (Nagy, Sanders & Ohm, 1988; Ojo & Evbuomwan, 1997; Pinstrup-Andersen & Pandya-Lorch, 1997). Problems experienced with extension services in Qwaqwa were discussed in Chapter 4. The small ruminant farmer views extension advice as extremely important, as 97 per cent of the 99 farmers indicated that they needed extension advice (Figure 5.7). The results on questions concerning the supply and demand of extension services are summarised in Table 5.11. The availability of government extension officers is rated by 51 per cent of the farmers as accessible and the availability of cooperative extension officers by 50 per cent of the farmers.

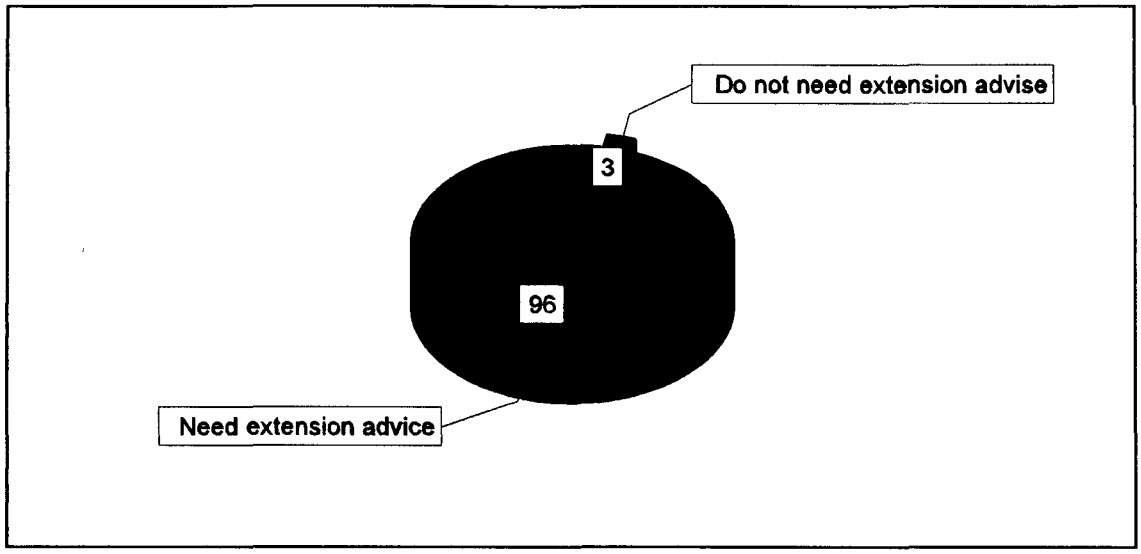

Figure 5.7: **Need for extension services**

Approximately half of the farmers have the perception that extension officers (government and cooperative) have the desired technical knowledge to assist them, but less than a third of the farmers feel that they have the desired financial knowledge to assist them (Table 5.11).

Table 5.11: **SUPPLY AND DEMAND FOR EXTENSION SERVICES**

Availability and accessibility of extension officers	**%**	
Government extension officers	51	
Cooperative extension officers	50	
Input supplier's extension officer	27	
Times visited by extension officers	**Median**	
Government extension officers	0	
Cooperative extension officers	0	
Input supplier's extension officer	0	
Total visits per year	3	
Perception of farmers whether extension officers have the desired level of technical and financial knowledge	**Number**	**%**
Technical:		
Government extension officers	46	47
Cooperative extension officers	51	52
Input supplier's extension officer	25	25
Financial:		
Government extension officers	24	24
Cooperative extension officers	31	31
Input supplier's extension officer	8	8

Visits by extension officers play an important role in the communication process of the diffusion of technology. However, the results on the number of these visits showed a median of zero and needs a more detailed discussion. The number of times that farmers in the total sample were visited by government extension officers varied between 0 and 24 per year, whereas 56 per cent farmers did not receive a single extension visit from the government extension officers in a year. Ten per cent of the farmers were visited once a year and nine per cent of the farmers 12 times a year. The cooperative extension officers also showed the same variation of zero to 24 visits a year. Fifty per cent of the farmers have not received a single extension visit from the cooperative extension officers in a year. Eight per cent of the farmers were visited four times a year. The visits by input supplier's extension officer varied between zero and ten times a year, and only 22 farmers received at least one visit per year.

The farmers thus received a median of three extension visits (from the three different extension sources available) per year. The number of visits a year of the three extension sources gave a median of zero visits, which is an indication that this section of data is very skewly distributed. A few farmers get a high number (up to 26 times) of visits per year and 23 per cent of the farmers are never visited by extension officers. Twenty-one per cent of the farmers receive one or two visits a year from extension officers.

5.10 INFORMATION SOURCES

The manner in which new technology messages are carried to the user or adopter is a further important tool for the technology transfer process. Information sources were also included as an explanatory variable that was tested for its significance in explaining technology transfer and adoption. Information sources approached by the farmers are summarised in Table 5.12 under the main categories: technical decisions, financial decisions, marketing decision and information on new technologies.

Table 5.12: **INFORMATION SOURCES USED FOR TECHNICAL, FINANCIAL AND MARKETING DECISIONS AND INFORMATION ON NEW TECHNOLOGIES**

Sources used for decision-making and information	Technical decisions* (%)	Financial decisions* (%)	Marketing decisions* (%)	Information on new technologies* (%)
Radio, television, extension publications (all leaflets periodicals), read in the press (newspapers, magazines, etc.)	32	10	15	25
Co-farmers - neighbours	23	12	19	11
Department of Agriculture - Extension officers	49	30	27	39
Cooperative extension officers	33	14	10	26
No one - use own physical or technical records	7	45	21	7
Bank manager	2	6	1	2
Supplier of inputs such as the cooperative manager	4	2	4	8
Veterinary surgeon	5	-	1	3
Sheering association chairperson	18	15	12	14
Livestock inspector, father, family, the media	6	2	-	5
Sell to buyer who is the closest to farm - do not consider different markets	-	-	16	-
Market agents	-	-	19	-
Compare the prices of the different markets	-	-	6	-

* n = 99

As can be seen in Table 5.12 the Department of Agriculture's extension officers are the main source of information that the local farmers approach when they have to make technical decisions. The second most important source of information is the cooperative extension services that are approached by 33 per cent of the farmers, followed by the media (radio, television, and extension publications) (32%), co-farmers (neighbours) (23%) and the chairperson of the sheering association (18%). All other sources of information have a relatively low importance for technical decision-making.

When it comes to financial decisions, the farmer's own records are the most important sources used. The extension officers of the Department of Agriculture are the second most important source approached, followed by the chairperson of the sheering association,

extension officers of the cooperatives and are co-farmers (neighbours) (Table 5.12). All other sources of information have a relatively low importance for financial decision-making.

With respect to the most important source of information to take marketing decisions, are the extension officers of the Department of Agriculture, followed by the farmer's own physical and technical records, co-farmers (neighbours), market agents, the media (radio, television, and extension publications), and the chairperson of the sheering association. All other sources of information have a relatively low importance for marketing decision-making.

The extension officers of the Department of Agriculture are the most important source approached when the farmers need information on new technologies. The second most important source of information is the cooperative extension officers, followed by the media (radio, television, and extension publications) that can be seen as information gathered by the farmer himself, as well as his own physical and technical records, chairperson of the sheering association and co-farmers (neighbours) (Table 5.12). All other sources of information have a relatively low importance for information on new technologies.

It is clear from the information obtained that the extension officers from the Department of Agriculture and the cooperatives, the farmer's own technical and financial records, the sheering association's chairperson and the media are the main sources approached by farmers in Qwaqwa when information is needed on new technologies and when making technical, financial and marketing decisions. The chairpersons of the sheering associations give advice at their own expenses. They are in an excellent position to establish the link between farmers and the extension services of the Department of Agriculture. It is therefore very important to provide better information and logistical assistance to these individuals in future technology transfer programmes and must be acknowledged in future agricultural policy on development of agriculture.

5.11 SMALL RUMINANT INFORMATION

This study concentrates on small ruminant livestock veterinary technologies, namely veterinary surgeon services and medication. Medication refers to the four major medication groups used in small ruminant farming, namely **external parasite remedies**, **internal parasite remedies**, **antibiotics** and **vaccination**. The small ruminants referred to in this study includes **mutton sheep**, **woolled sheep**, **Boer goats** and **Angora goats**.

5.11.1 Physical and financial information on small ruminants

The only livestock production information available of Qwaqwa at the beginning of this study was broadly defined as sheep and goats and their numbers. No information was available on mutton and woolled sheep or Boer and Angora goats. The sample selection of this study was therefore based on sheep and goat farmers. After the data was processed, it was realised that the total sample had 53 mutton sheep herds, 42 woolled sheep herds, 29 Boer goat herds and 43 Angora goat herds (Table 5.13).

Table 5.13: **SMALL RUMINANT NUMBERS, INCOME AND LOSSES**

Median	Small ruminants			
	Mutton sheep	Woolled sheep	Boer goats	Angora goats
Sample (n)	53	42	29	43
Rams	2	1	1	1
Ewes	22	25	20	20
Total small ruminants	34	41	31	42
Weaning percentage	58	50	50	50
Income	R1 500	R2 950	R860	R1 300
Losses: Dead	2	3	1	1
Stolen	0	0	0	0

As can be seen from Table 5.13 the median herd sizes of the different types of small ruminants are very similar. The median weaning percentage for mutton sheep is 58 per cent and for woolled sheep, Boer and Angora goats it is 50 per cent. The median gross farm income per year varies between R860 for Boer goats and R2 950 for woolled sheep. The number of sheep/goats that died in 1997 is quite low when compared with the losses

of small ruminants during the winter of 1996 when some farmers lost nearly their total herds. The number of sheep that died in 1997 varied from 0 to 70 and the number stolen varied from 0 to 105. The number of goats that died varied from 0 to 50 and the number stolen varied from 0 to 15. The theft of livestock started to decline when the farmers started their own anti-livestock theft unit (Komako, 1998).

5.11.2 Breeding technology information

The breeding technology information concentrates on the usage of registered and graded rams and mating seasons. Registered and graded rams are genetically superior animals that may improve the value and the production potential of the herds. The use of such rams is advocated and made available by the extension services of the Department of Agriculture in Qwaqwa. The use of a mating season implies that rams must be removed from the herd for a certain period of the year. Mating seasons are therefore quite difficult to use in a communal grazing system with frequent contact of different herds. The results on breeding technology are summarised in Table 5.14.

Table 5.14: **USAGE OF RAM TECHNOLOGY**

Types of rams used*	Small ruminants							
	Mutton sheep (%) (n=53)		Woolled sheep (%) (n=42)		Boer goats (%) (n=29)		Angora goats (%) (n=43)	
	No.	%	No.	%	No.	%	No.	%
Borrowed rams	1	2	5	12	2	7	1	2
Any rams	5	9	0	0	0	0	0	0
Local grade rams	26	49	3	7	8	28	8	19
Registered and grade rams	7	13	27	64	5	17	16	37
Community owned rams	1	2	1	2	2	7	1	2
Own bred rams	14	26	11	26	11	38	15	35
Boer goat ram on Angora ewes	0	0	0	0	0	0	1	2
Total	54	100	47	100	28	100	42	100

* A farmer could use more than one type of ram.

The use of ram technology shows a great variation. Borrowed rams refer to rams borrowed from co-farmers; any rams refer to the purchase of any type of ram that the farmer can get hold of; local grade rams refer to rams bought from local breeders; registered and grade rams are bought from breeders outside Qwaqwa; communal owned rams are rams that are communally bought and own bred rams are rams bred on the farmer's own herds.

Woolled sheep herds have the highest rate of adoption of registered and graded rams (local grade rams included) - 71 per cent of the 42 woolled sheep herds - followed by mutton sheep herds with 62 per cent of the 53 mutton sheep herds, Angora goats with 56 per cent of the 43 Angora goat herds and Boer goats which showed the lowest adoption rate of ram technology with 45 per cent of the 29 Boer goat herds using registered and graded rams (including local grade rams).

Thirty-eight per cent of the Boer goat farmers, 35 per cent of the Angora goat farmers and 26 per cent of the mutton sheep and woolled sheep farmers make use of their own bred rams. Farmers using their own bred rams are running the risk effects of inbreeding over time. Sheep farmers (mutton and woolled) are 91 in total, from which only four have both types of sheep. Three per cent of these farmers are using registered rams only with one of the types of sheep and only one per cent are using registered rams with both types of sheep. According to Claassens (1998) the lack of ram technology transfer after 1994 is one of the reasons why a considerable portion of the farmers are using own bred rams. As discussed in Chapter 3, the extension programme deteriorated after 1994 as discussed in Chapter 3 and ram technology transfer was severely affected by the policy change by the Department of Agriculture.

Reasons for not using ram technologies were not indicated for the different types of small ruminants separately. Sixty-six per cent of the small ruminant farmers are using ram technologies for registered and graded rams. The reasons why ram technology was not used by 34 per cent of the farmers are summarised in Table 5.15. The high price of the registered and graded rams and the cash available to buy them was the main reasons for not adopting ram technologies. The accessibility and availability of rams were also important reasons why ram technologies were not adopted.

Table 5.15: **REASONS FOR NOT USING RAM TECHNOLOGY**

Reasons for not using registered or graded rams*	n=31	%
Rams are too expensive	14	45
Have no money (cash) available to buy rams	15	48
Cannot get credit to buy rams	1	3
Rams are not easy accessible	5	16
Have no transport to get the rams to the farm	5	16
The transport is too expensive to get the rams to the farm	4	13
Rams will not have a large enough effect on reproduction levels to pay for the extra expenses	5	16
It will increase the production risk of the farm	2	6
It will increase the financial risk of the farm due to higher debt	2	6
Decent rams are not freely available	4	13
Satisfied with own rams	2	6
Use communal rams	1	3
No fencing – infrastructure (cannot keep rams on communal veld with own ewes)	0	0
Do not know ram producers	0	0
Just started farming	5	16
Farm for own consumption	0	0

* Farmers were allowed to give more than one reason.

Mating season is also a very important breeding technology that can help to increase the reproduction levels of small ruminants (Devendra & McLeroy, 1982). Seventy-five per cent of the small ruminant farmers have adopted mating season technology. The seasons in which the rams are mating the ewes, are summarised in Table 5.16.

Table 5.16: **USAGE OF MATING SEASON TECHNOLOGY**

Mating season	Small ruminants							
	Mutton sheep (n=53)		Woolled sheep (n=42)		Boer goats (n=29)		Angora goats (n=43)	
	No.	%	No.	%	No.	%	No.	%
Summer	5	9	7	17	3	10	5	12
Autumn	22	42	24	57	21	72	32	74
Winter	5	9	2	5	0	0	0	0
Spring	6	11	2	5	1	3	1	2
Total used mating seasons	38	72	35	83	25	86	38	88

Seventy per cent of the mutton sheep herds, 83 per cent of the woolled sheep herds, 86 per cent of the Boer goat herds and 88 per cent of the Angora goat herds are mated in one of the mating seasons of the year. The rest of the farmers are keeping the rams with the ewes throughout the year. The autumn mating season (spring lambing/kidding) is the most used season by the adopters of mating season technology.

5.11.3 Reasons for farming with small ruminants

Farmers were asked to prioritise (from 1 as not important to 4 as very important) reasons for farming with different types of small ruminants. If a farmer had more than one type of small ruminant, he had to rate the importance (1-4) of several reasons for farming, which included: for normal commercial farming, investment, source of money, risk reduction, own consumption, cultural or other reasons. The analysis for each type of small ruminant and for each reason for farming was complicated as the number of herds in each type of reason was too low to allow testing individual types of small ruminants. It was therefore decided to generalise this variable by only analysing the answer given to the larger herd of the farmer and to the score given to the importance of farming for normal (commercial) reasons. The results are summarised in Table 5.17.

Table 5.17: **REASONS FOR FARMING WITH SMALL RUMINANTS**

Item	Median rating
For normal commercial farming	2
Other Reasons:	
As an investment	1
As a source of money in case of emergency	1
To reduce risk diversification	0
For cultural and religious reasons	0
For own consumption	1
Other (Because he likes sheep)	0

* 4 = Very important
3 = Important
2 = Less important
1 = Unimportant
0 = Option not chosen

Normal (commercial) farming was rated a median of two, followed by farming for investment purposes, as a source of money in case of emergency and farming for own consumption with a median of one. The rest of the reasons had a zero median rating. These results indicate that the small ruminant farmers in Qwaqwa tend to be more commercially driven than towards culturally and subsistence farming.

5.11.4 Livestock veterinary technologies

The adoption of veterinary surgeon services and four separate medication technologies are five dependent variables, as described in Chapter 3, which will be analysed in this study towards the extent or level of adoption. Each section will be introduced by a definition of the different adoption levels. The definition of the different levels of adoption for the different medication groups were done in collaboration with a panel, which consisted of Naude, Erasmus, Greyling, De Wet and Schwalbach. The four medication groups were identified by means of their specific use and cure for the groups of parasites and diseases.

5.11.4.1 Veterinary surgeon services

The following have been defined with regard to the adoption of veterinary surgeon services:

- ***Adopter:*** Uses veterinary surgeon services at least once a year.
- ***Non-adopter:*** Uses no veterinary surgeon services.
- ***Potential adopter:*** A non-adopter who would have used veterinary surgeon services if they were made available and accessible.

The usage of veterinary surgeon services are shown in Figure 5.8. Veterinary surgeons are one of the crucial persons in the medication technology transfer process (Bhattacharyya *et al.*, 1997). This is one of the main reasons why it was decided to include this technology in this study as a dependent variable.

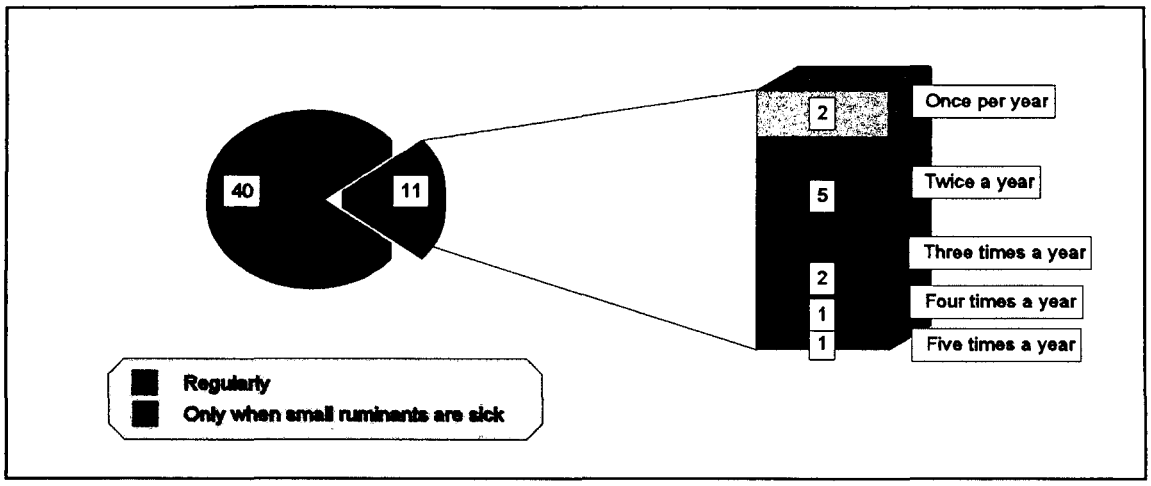

Figure 5.8: **Usage of veterinary surgeon services**

Fifty-two per cent of the 99 farmers make use of a veterinary surgeon at least once a year. Those identified as adopters of veterinary surgeon services amounted to 51 farmers and the non-adopters were 48. The 35 non-adopters who gave reason number 4 and/or 12 as a reason (Table 5.18) for not adopting veterinary surgeon services are classified as potential adopters. The adopters and potential adopters totalled 87 per cent of the farmers in the survey. The non-adopters of veterinary surgeon services totalled 13 per cent of the farmers.

Of the 51 farmers who use a veterinary surgeon, 78 per cent use them only when their animals are sick and only 22 per cent are using a veterinarian on a regular basis. The majority of farmers who visit the veterinary surgeon on a yearly basis, do so twice a year (Table 5.18).

Table 5.18: **USAGE OF VETERINARY SURGEON SERVICES**

Reasons for not using veterinary surgeon services	Total number (n = 48)	%
1. Veterinary surgeon services are too expensive	25	52
2. Have no money (cash) available to afford veterinary surgeon services	10	21
3. Cannot get credit to make use of veterinary surgeon services	5	10
4. The veterinary surgeon services are not easily accessible	34	71
5. Have no transport to take the sick animals to the veterinarian	15	31
6. The veterinary surgeon services will not have a large enough effect on production levels to pay for the extra costs involved	2	4
7. It will increase the production risk of the farm	0	0
8. It will increase the financial risk of the farm due to higher debt	8	17
9. Involved in organic farming	0	0
10. Cultural reasons	0	0
11. Veterinary surgeon services are not freely available	30	63
12. Buy medication and use it without the help of veterinary surgeon	1	2
13. Do not need a veterinary surgeon - no diseases	1	2
14. Own knowledge of small ruminants enough	1	2

It is evident from Table 5.18 that the most important reasons why veterinary surgeon services were not being used by 48 of the small ruminant farmers, are that the veterinary surgeon services are not easily accessible (71%), not freely available (63%), too expensive (52%), they have no transport to take sick small ruminants to the veterinary surgeon (31%) and they cannot afford veterinary surgeon services (21%).

5.11.4.2 Adoption of external parasite remedies

The following types of adopters were identified with regard to external parasite remedies (Erasmus, 1998; McDonald, 1998; Schwalbach, 1998). The definitions are the same for all four types of small ruminants.

- ***Full adopter:*** Treats small ruminants two times per year.
- ***Non-adopter:*** No treatments.
- ***Partial adopter:*** Treats small ruminants once a year.
- ***Over-adopter:*** Treats small ruminants more than two times a year.
- ***Wrong adopter:*** Uses only a wrong remedy for external parasites.

According to McDonald (1998), external parasites (ticks and scab) are not a major problem in Old and New Qwaqwa because of the relatively low temperatures. The remedy Ivomec controls external as well as internal parasites. The use of external parasite remedies relies on what the farmer sees on the animals and in a herd intervention. An average of two external parasite breakouts can be expected in a year under "normal circumstances" (Naude, 1998). Over-adoption of external parasite remedies is not critical because ticks and scab cannot easily build resistance to these drugs if over-adoption occurs. The major disadvantage of the over-adoption in this case is that the farmer will be wasting his money. According to Erasmus (1998) the usage of a wrong remedy in combination with a correct remedy for external parasites is not a major issue. If a farmer has indicated that Ivomec is used as an internal parasite remedy and not as an external parasite remedy, it will be assumed that the farmer is also an adopter of internal parasite remedies, as these remedies have a double internal/external parasite effect simultaneously (IVS Desk Reference, 1998).

The list of external parasites remedies used is presented in Table 5.19. HI-TET is the only wrong remedy used in this category. A vast range of external parasite remedies is used in Qwaqwa. Each one has its own usage specifications, which increases the need for extension or other help to correctly applying these remedies.

Table 5.19: LIST OF EXTERNAL PARASITE REMEDIES USED
Commercial name of remedy (*Active principle* *)
Drastic Deadline *(Flumethrin 1%)*
Ivomec *(Ivermectin 1%)*
Zipdip *(Triazophos 40%)*
Littlesdip *(Carbolic acid)*
Triatix *(Amitraz 1%)*
Clout *(Deltamethrin 1%)*
Dazzle *(Diazinon 30%)*
HI-TET 300 LA** *(Oxytetracycl. HCl 300 mg/ml)*
Zeropar *(Chlorfervinphos 30% Alphamthrin 30%)*
Sumiplus *(Clorfenvinphos 30%, Esfesvalerate 2,2%)*
Topclip *(Diazinon)*
Paracide *(Alphamethrin 7%)*
Keroldip *(Carbolic acid)*

* The active principle is shown in brackets.

** Wrong remedy for external parasites.

The results of external parasite remedy adoption are summarised in Table 5.20. No traditional remedies were used as external parasite remedies by the local farmers.

Table 5.20: **SUMMARY OF EXTERNAL PARASITE REMEDY ADOPTION**

Adopters	External parasites (%)			
	Mutton sheep (n=53)	Woolled sheep (n=42)	Boer goats (n=29)	Angora goats (n=43)
Non-adopters	0	0	0	0
Partial adopters	13	9	14	12
Full adopters	62	69	45	58
Over-adopters	23	17	34	30
Wrong adopters	2	5	7	0
Median times per year	2	3	4	3
Traditional remedies (n)	0	0	0	0

The application of external parasite remedies on all types of small ruminants varies from once a year to ten times a year. This is an indication that small ruminant farmers in Qwaqwa are aware of the existence of external parasite remedies and that the animals must be treated for these parasites.

There were no non-adopters, seven partial adopters, 33 full adopters, 12 over-adopters and one wrong adopter using only HI-TET (twice a year) as an external parasite remedy for **mutton sheep**.

There were no non-adopters, four partial adopters, 29 full adopters, seven over-adopters and two wrong adopters who only use HI-TET, a wrong remedy for external parasites on **woolled sheep**. The median times that correct external parasite remedies were used was three times a year.

There are no non-adopters, four partial adopters, 13 full adopters, 10 over-adopters and two wrong adopters for **Boer goats**. The wrong adopters used only HI-TET (twice a year). The median times of correct application of external parasite remedies was four times a year.

There were no non-adopters, five partial adopters, 25 full adopters, 13 over-adopters and no wrong adopter for **Angora goats**. The median times of correct external parasite remedies application was three times per year.

5.11.4.3 Adoption of internal parasite remedies

The following types of adopters were identified with regard to external parasite remedies (Erasmus, 1998; Naude, 1998, McDonald, 1998; Schwalbach, 1998). The definitions are the same for all four types of small ruminants.

- ***Full adopter:*** Uses remedies acting against roundworms four to six times, tapeworms two to four times and nasal worms more than once per year.

- ***Non-adopter:*** No remedies used.
- ***Partial adopter:*** Uses **less** than the defined levels for a full adopter in any of the groups.
- ***Over-adopter:*** Uses remedies acting against roundworms, tapeworms and nasal worms **more** than the defined times per year in any of the groups.

It is very difficult to define a partial, full and over-adopter with regard to internal parasite medication technology as the treatments necessary to deworm small ruminants will vary from farm to farm and from herd to herd. Factors like population density of small ruminants, rainfall, temperature and breed also play a role in the burden of internal parasite infestation. The level of environmental contamination, the condition of the herd and the level of management also plays an important role on the number of treatments per year. Over-adoption of internal parasites medication technology is dangerous in the sense that it can result in a resistence built-up of a resistance against the specific remedy. After an in-depth discussion with Erasmus, Naude, McDonald and Schwalbach (1998), it was decided that the modelling will focus on the most common or important internal parasites in Qwaqwa, namely roundworms, tapeworms and nasal worms.

The list of internal parasite remedies used is presented in Table 5.21. HI-TET is the only remedy listed that is a wrong remedy for internal parasites. Some of these remedies have simultaneous action against two or three groups of internal parasites. This aspect was taken into consideration when classifying these farmers.

Table 5.21: **LIST OF CONVENTIONAL INTERNAL PARASITE REMEDIES USED AND THEIR RESPECTED RANGE OF ACTION**

Name of remedy (*Active principle* *)	Acting against			
	Roundworm	Tapeworm	Nasal worm	Liver fluke
Ranide *(Closantel 75 mg/ml)*	✔		✔	✔
Ivomec *(Ivermectin 1%)*	✔		✔	
Valbazen *(Albendazole 1,9%)*	✔	✔		✔
Lintex M/Ex-A-Lint *(Niclosamide 75%)*		✔		
Systemex *(Oxfendazole)*				✔
HI-TET 300 LA** *(Oxytetracycl. HCl 300 mg/ml)*				
Multispec *(Mebendazole 5%)*	✔	✔		
Tramisol Plus *(Levamisole HCl 2,5% Rafoxanide 2,5%)*	✔		✔	✔
Valbantel *(Albendazole 1,9%, Na-closantel 3%)*	✔	✔	✔	✔
Seponver Plux *(Closantel 25 mg/ml, Mebendazole 37,5 mg/ml)*	✔	✔	✔	✔
Prodose Lint *(Niclosamide 20%)*	✔	✔		
Ripercol *(Levamisole HCl 30 mg/ml)*	✔			
Flukiver *(Closantel 50 mg/ml)*				✔

* The active principle is shown in brackets.
** Wrong remedy for internal parasites.
Source: IVS Desk Reference (1998).

The results of the internal parasite remedy adoption are summarised in Table 5.22. A number of farmers make use of traditional remedies (natural herbal remedies) for the treatment of internal parasites (11 mutton sheep herds, 10 woolled sheep herds, 11 Boer goat herds and 17 Angora goat herds). The effect of these remedies is not known and therefore not considered in this study. More research on these herbal/ traditional remedies is recommended.

Table 5.22: **SUMMARY OF INTERNAL PARASITE REMEDY ADOPTION**

Adopters	Internal parasites (%)			
	Mutton sheep (n=53)	Woolled sheep (n=42)	Boer goats (n=29)	Angora goats (n=43)
Non-adopters	4	0	3	0
Partial adopters	66	67	66	72
Full adopters	13	19	10	7
Over-adopters	17	14	21	21
Traditional remedies (n)	11	10	11	17

Four per cent of the **mutton sheep** farmers were non-adopters, 66 per cent partial adopters, 13 per cent full adopters and 17 per cent over-adopters. Amongst the **woolled sheep** farmers there were no non-adopters, 67 per cent partial adopters, 19 per cent full adopters and 14 per cent over-adopters. Three per cent of the **Boer goat** farmers are non-adopters, 66 per cent are partial adopters, 10 per cent are full adopters and 21 per cent over-adopters. Amongst the **Angora goat** farmers there are no non-adopters, 72 per cent are partial adopters, seven per cent full adopters and 21 per cent over-adopters.

The variation in the utilisation of remedies against three of the most important internal parasite groups is summarised in Table 5.23. Mutton sheep farmers showed a great variation of dosing times of between once and 12 times per year.

The variation in dosing times is the greatest amongst the woolled sheep and Angora goat herds for tapeworms. The dosage given varies from zero to 30 times per year in the woolled sheep herds and once to 30 times in the Angora goat herds. The second highest variation is in the dosage of roundworms also amongst the woolled sheep and Angora goat herds. All the maximum dosings, except for roundworms in the Boer goat herds, are more than double of the recommended number of times per year.

Table 5.23: **MINIMUM, MAXIMUM, MEAN AND MEDIAN TIMES DOSED AGAINST THE THREE MOST IMPORTANT INTERNAL PARASITES**

Internal parasite	Mutton sheep (n=53)	Woolled sheep (n=42)	Boer goats (n=29)	Angora goats (n=43)
Roundworms				
Minimum	0	0	0	0
Maximum	12	24	10	24
Mean	3	4	3	4
Median	3	4	3	3
Tapeworms				
Minimum	0	0	0	1
Maximum	12	30	9	30
Mean	3	5	4	6
Median	2	3	4	4
Nasal worms				
Minimum	0	0	0	0
Maximum	8	10	10	7
Mean	2	2	2	1
Median	2	1,5	1	0

The median times of dosing for roundworms in the woolled sheep herds on the minimum level as defined for the rest, is lower than the recommended programme. This is an indication that full adoption of roundworm remedies will be low. The median times dosed for tapeworms and nasalworms are within the definition of full adopters for most of the four types of small ruminants. However, the median times dosed for roundworms are lower than the minimum recommended programme. This is an indication that the full adoption of tapeworm and nasalworm remedies is relatively high and full adoption of roundworm remedies will be relatively low. It is therefore expected that full adoption of internal parasite remedies will be quite low and partial adopters quite high. This will be further discussed in Chapter 7.

5.11.4.4 Adoption of antibiotics

The following types of adopters were identified with regard to antibiotics (Erasmus, 1998; McDonald, 1998; Schwalbach, 1998). The definitions are the same for all four types of small ruminants.

- ***Full adopter:*** Uses both systemic and local antibiotics to treat sick small ruminants.
- ***Non-adopter:*** Uses no antibiotics.
- ***Partial adopter:*** Uses only either systemic or local antibiotics, but not both.

This category has full adopters, partial adopters and non-adopters. The adopter is the farmer who uses both systemic and local antibiotics, a partial adopter is a farmer who uses systemic or local antibiotics and the non-adopter uses either a wrong medication or no antibiotics. The usage of antibiotics is important in any small ruminant farm and eye infections were identified by Naude (1998) as one of the most important ailments of small ruminants in Qwaqwa that requires the use of antibiotics. Respiratory and digestive bacterial infections are also very common problems in small ruminant farming (Schwalbach, 1998).

The list of antibiotics used in Qwaqwa is presented in Table 5.24. Thibenzole, a worm remedy, is the only wrong remedy used in this category and only one woolled sheep farmer used antibiotics, eye powders and Thibenzole. This farmer can therefore be seen as an adopter of antibiotics.

Table 5.24: **LIST OF ANTIBIOTICS USED**

Name of remedy (*Active principle* *)
Terramycin 100 (*Oxytetracycline, HCl 100 mg/ml*).
Terramycin Eye Powder (*Oxytetracycline, HCl, Benzocaine 20 mg/g*).
Wound aerosol NF (*Dichlorophen 1%, Propetamphos 0,25%, Pine oil 2,5%*).
Airbiotic wound spray .
HI-TET 300 LA (*Oxytetracycline, HCl 300 mg/ml*).
Doxymycin (*Doxycline 25 mg/ml*).
Thibenzole (*Thiabendazole 17,6% m/v*).

* The active principle is shown in brackets.

The results of antibiotic adoption are summarised in Table 5.25. Antibiotic technology amongst farmers were fully adopted by 21 per cent of the woolled sheep and Boer goat farmers, 15 per cent of the mutton sheep farmers and 11 per cent of the Angora goat farmers. Sixty-nine per cent of the woolled sheep farmers, 66 per cent of the mutton sheep farmers, 30 per cent of the Angora goat farmers and 18 per cent of the Boer goat farmers partially adopted antibiotics. Nineteen per cent of the mutton sheep and Angora goat farmers, 17 per cent Boer goat farmers and 10 per cent of the woolled sheep farmers are non-adopters of antibiotics on their herds.

Table 5.25: **SUMMARY OF ANTIBIOTICS ADOPTION**

Adopters	Use of antibiotic technology (%)			
	Mutton sheep (n=53)	Woolled sheep (n=42)	Boer goats (n=29)	Angora goats (n=43)
Non-adopters	10 (19%)	4 (10%)	5 (17%)	8 (19%)
Partial adopters	35 (66%)	29 (69%)	18 (62%)	30 (70%)
Full adopters	8 (15%)	9 (21%)	6 (21%)	5 (11%)
Traditional remedies (n)	0	3	2	0

5.11.4.5 Adoption of vaccines

According to Naude (1998) the minimum recommended vaccination programme for small ruminants in Qwaqwa is pulpy kidney (twice a year for mutton sheep, woolled sheep, Angora goats and Boer goats), blue tongue (once a year for all four types of small ruminants) and black quarter (once a year for all four types of small ruminants). Non-adopters are using no vaccination at all and partial adopters are those farmers who did use vaccination but not the minimum recommended programme. Farmers who used a wrong remedy as a prophylactic for a certain disease instead of a vaccine, for example Terramycin, can be seen as wrong adopters. If they only use wrong remedies, they are seen as non-adopters. There are only one mutton sheep farmer, two woolled sheep farmers and two Boer goat farmers who used no vaccinations and wrong remedies.

The following types of adopters were identified with regard to vaccines (Erasmus, 1998; McDonald, 1998; Schwalbach, 1998). The definitions are the same for all four types of small ruminants.

- ***Full adopter:*** Uses all the minimum recommended vaccinations - pulpy kidney twice, blue tongue and black quarter once a year (No farmers in sample).
- ***Non-adopter:*** Uses no vaccination to prevent diseases.
- ***Partial adopter:*** Uses vaccination but not all the minimum recommended vaccinations.

This category of medication can be described as a preventative measure for the most common diseases that could be prevented by vaccination. Usually, vaccines should be used according to a specific programme, but sometimes after an animal has died with a certain suspected disease, farmers use vaccination as a late effort to prevent an outbreak and serious economical losses.

A list of vaccines used in Qwaqwa for disease control is presented in Table 5.26. The remedies Ivomec, HI-TET and Vitamin-A are not vaccines to prevent diseases as indicated in the mentioned table, but were used by some of the farmers for this purpose.

Table 5.26: **LIST OF VACCINES USED IN QWAQWA TO PREVENT SMALL RUMINANT DISEASES**

Name of vaccine (*Active principle* *)
Pulpy kidney vaccine
Blue tongue vaccine
Black quarter vaccine
Ivomec** *(Ivermectin 1%) (Ivermectin 1%)*
Botulism ("Lamsiekte")
HI-TET 300 LA** *(Oxytetracycl. HCl 300 mg/ml)*
Anhrax vaccine
Stiff sickness vaccine
Vitamin A Forte** *(A 500 000 iu, D 50 000 iu, E 50 iu)*

* The active principle is shown in brackets.

** Wrong remedy for diseases.

The results of vaccine adoption are summarised in Table 5.27. There are no full adopters according to the proposed minimum vaccination programme in any of the small ruminant types. There are only partial adopters and non-adopters in this category of medication technology. Eighty-three per cent of the mutton sheep farmers, 86 per cent of the woolled sheep farmers, 72 per cent of the Boer goat farmers and 72 per cent of the Angora goat farmers are partial adopters. Seventeen per cent of the mutton sheep farmers, 14 per cent of the woolled sheep farmers, 28 per cent of the Boer goat farmers and 28 per cent of the Angora goat farmers are non-adopters of vaccination technology. Vaccination patterns are too wide to work on a percentage for the partial adopters.

Table 5.27: **SUMMARY OF VACCINE ADOPTION**

Adopters	Diseases (Vaccination)			
	Mutton sheep (n=53)	**Woolled sheep (n=42)**	**Boer goats (n=29)**	**Angora goats (n=43)**
Non-adopters	9 (17%)	6 (14%)	8 (28%)	12 (28%)
Partial adopters	44 (83%)	36 (86%)	21 (72%)	31 (72%)
Full adopters	0	0	0	0
Traditional remedies (n)	0	0	0	0

Stiffsickness vaccine is an example of a wrong medication as only cattle can get this disease (Hunter, 1993). The clinical symptoms of severe nasal excretion are confused with a heavy attack of nasal worms, which is actually an internal parasite, or dust irritation (Naude, 1998). The three farmers who indicated that they vaccinate for botulism, also vaccinate for pulpy kidney and are classified as partial adopters. The same clinical signs are not seen amongst sheep but they are equally susceptible. The impaired sheep show sings of emaciation and degenerated feeding habits (Blood, Henderson & Radostits, 1997). There were three farmers who indicated that they vaccinate for stiffsickness, of which two also vaccinated for pulpy kidney and the other farmer vaccinated for black quarter and also giving Vitamin A wrongly. All three these farmers are classified as partial adopters.

5.12 AGRICULTURAL SUPPORTIVE INSTITUTIONS

Agricultural supportive institutions (cooperative, input suppliers and banks) are in general not freely or easily accessible and available to farmers in Qwaqwa. Figure 5.9 shows the accessibility level of the different institutions, as perceived by the local small ruminant farmers.

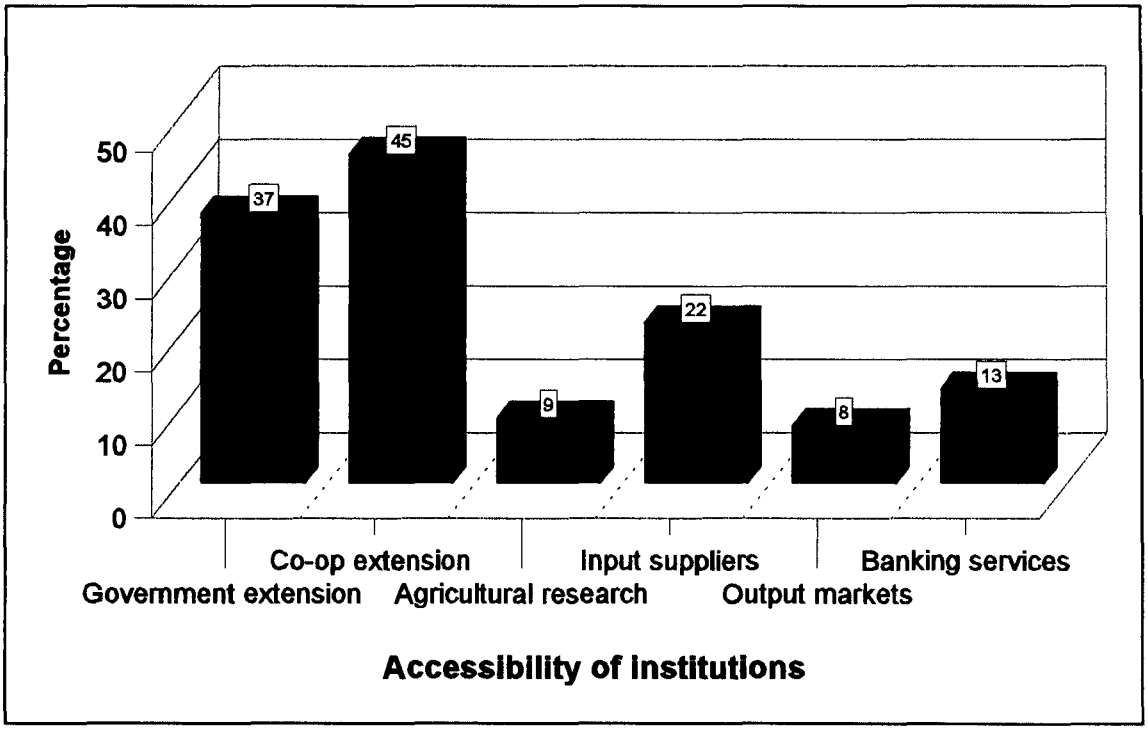

Figure 5.9: **Accessibility of institutions to farmers (%)**

Forty-five per cent of the farmers felt that the cooperative extension system is accessible and only 37 per cent regard the government extension system as accessible. Agricultural research is accessible in only six per cent of the cases and input suppliers in 22 per cent of the cases. Output markets are accessible in only eight per cent of the cases, and perhaps the most shocking result is that banking services are regarded as accessible to 13 per cent of the 99 farmers.

5.13 CONCLUSION

The educational level of the vast majority of farmers is very low. This is reflected on the relatively low capacity of need in English or Afrikaans, essential abilities for farmers to correctly adopt medication technologies with minimal assistance. Perhaps this is the main reason why a vast majority of the farmers regard the extension services as very important and a good part of the farmers approach them for technical, financial, marketing advice and information on new technologies.

The number of extension visits to farmers in general is very low, with a considerable part of the farmers not being visited at all. This is the reason why the extension services are considered as not easily available or accessible. The low availability of roads and transport discussed in Chapter 4, increased the transaction costs involved to obtain new technology information. These conditions in Qwaqwa, similar to most of the former homelands, are major constraints to an efficient diffusion/adoption of new livestock technologies which are essential to improve livestock production levels and the quality of life for local farmers.

Chapter 6

ADOPTION OF VETERINARY SURGEON SERVICES

6.1 INTRODUCTION

Diseases and parasites form one of the main constraints to sheep and goat production. The economic losses due to diseases and parasites are considerably high, especially in densely populated areas with poor nutritional grazing value, and where veterinary and diagnostic services are weak (Devendra & McLeroy, 1982). Animal disease control in developing countries has been universally the concern of government and public service (Wilson & Lebbie, 1996).

The veterinary surgeon is the best qualified professional who, when integrated in an extension network service with experienced extension and health officers, can control diseases and parasites by using modern medication technologies. These livestock technologies must be progressively adopted and mastered by livestock farmers, with the help of extension or animal health officers under close supervision of a veterinary surgeon.

In the past, the government used to station at least one veterinarian in the region and provided veterinary surgeon services and extension to former homeland farmers in Qwaqwa. State veterinarians provided free services to farmers who could buy medication at a subsidised price. These conditions were essential to an adequate diffusion and adoption of new livestock veterinary technologies.

Agricultural development programmes and awareness campaigns for farmers in the former homelands in rural areas in South Africa have increased over the past 10 years. However, many of these programmes were not successful due to insufficient technology diffusion programmes (Kirsten, 1994).

After the general elections of 1994 the Department of Agriculture went through many policy changes that have resulted in less availability, accessibility and affordability of veterinary surgeon services. This became a major constrain to the adoption and usage of veterinary surgeon services by the livestock farmer in the former homelands, as the subsidised veterinary surgeon services were withdrawn by the government. In this process a number of farmers who want to adopt this technology could not obtain or afford it. These farmers will be described in this section as potential adopters. No research has been done in South Africa to determine the characteristics of these adopters and potential adopters of veterinary surgeon services and the important variables (predictors) contributing to the adoption of this technology.

Identifying the variables that differentiate between those who adopt or are willing or wanting to adopt veterinary services, and those who do not, can have promising and cost-saving impacts on the planning and execution of future programmes. In the past the conventional approach of adoption or non-adoption was used in most of the adoption studies (Feder, Just & Zilberman, 1985; Lin, 1995). In these studies adopters were seen as those farmers using the technology during the survey period, and in theory an assumption is made that the supply of a new technology (inputs or services) is elastic. This definition is too restrictive for developing countries, as the supply of inputs or services embodying the new technology, is often not elastic due to its inaccessibility (Nichola, 1996). If the inputs or services are in short supply or excess demand (need), not all the farmers who would like to use these inputs or services would be able to obtain or afford them.

An effort will be made in this chapter to determine whether the characteristics of the potential adopters gravitate more to those of the adopters or to those of the non-adopters by testing the hypothesis that the variables predicting adoption and potential adoption are different and that actual adoption would be influenced by those variables determining the rationing of inputs or services. The characteristics and the possible predictors of the

different adoption groups and its combinations of veterinary surgeon services are presented in Annexure C. The identified predictors of adoption of veterinary surgeon services (using the conventional definition) by small ruminant farmers in Qwaqwa will be compared with those of the adapted definition which includes both adopters and would-be (potential) adopters by using a logit modelling approach. The application of the theory of Von Thünen (Barlowe, 1978) within the transaction cost concept will be used as an illustration of farmers who want to use veterinary surgeon services but are unable to do so due to its inaccessibility as well as the unavailability thereof at certain cost levels and the location of the farm..

It was hypothesised that family size, indebtedness, literacy and arithmetic abilities of farmers, availability of credit, information sources approached to make financial and marketing decisions and local markets will not influence adoption of this technology. These variables were therefore excluded from the veterinary surgeon services function in an effort to reduce the number of variables. It was also argued that family size will not determine whether a farmer will use veterinary surgeon services or not. Indebtedness has its origin from crop production and should not influence the decision whether to adopt veterinary surgeon services or not.

6.2 RESULTS AND DISCUSSION

The aim of this section is to present the characteristics of the different adoption groups (farmers), identify possible predictors of adoption (p-values $\leq 0,15$) to be included in the different logistic models and to discuss the empirical results of the different models fitted. For veterinary surgeon services two logit models are fitted in this chapter with the following dependent variables:

- Adopters *versus* potential adopters and non-adopters (conventional definition).
- Adopters and potential adopters *versus* non-adopters (adapted definition).

Adopters of veterinary surgeon services were defined as follows:

- ***Adopters*** (n = 51): use veterinary surgeon services at least once per year.
- ***Potential adopters*** (n = 35): would have used veterinary surgeon services if it were available or accessible.

- ***Non-adopters*** (n = 13): do not use and would not use veterinary surgeon services under any circumstances.

The potential adopters were first grouped with the non-adopters (n = 48) (conventional definition) and then with the adopters (n = 86) (adapted definition) in two different analyses to identify the predictors affecting the specific group of adopters. The characteristics of the adoption groups are presented by using the definition of adopters (A) (n = 51), potential adopters (Pot/A) (n = 35) and non-adopters (N/A) (n = 13) as given above.

The continuous variables with the possible predictors are summarised in Annexure C, Table C.1. The percentage distribution of the categorical variables in the different adoption groups are summarised in Annexure C, Table C.2.

The probit and logit models presented similar results. For the sake of brevity only the results of the logit model are presented in Table 6.1 and 6.2. Of the 13 possible predictors (farming experience with livestock, farming efficiency, management skills, total livestock income per livestock unit (LSU), extension officer visits, sheep LSU's as percentage of total small ruminant LSU's, training sources on medication usage, roads, transport, institutions [government and cooperative extension and agricultural research], suppliers of inputs, location of farming [Old Qwaqwa] and breeding technology) used in the estimation of the first logit model based on the conventional definition (adopters *versus* potential and non-adopters), four (one continuous and three categorical variables) were retained (p-values $\leq 0,15$) in the final model (Table 6.1). These predictors therefore contribute significantly to the adoption of veterinary surgeon services (conventional definition).

In the second logit model, using the adapted definition (adopters and potential adopters *versus* non-adopters), five possible predictors (farming efficiency, mortality rate, sheep LSU's as percentage of total small ruminant LSU's, information sources approached for technical decisions and breeding technology) were used, from which three (one continuous and two categorical variables) were retained in the final considered model (Table 6.2). These predictors therefore contribute significantly to the adoption of veterinary surgeon services (adapted definition) and can differentiate between adopters and potential adopters in Qwaqwa.

Table 6.1: **ADOPTION OF VETERINARY SURGEON SERVICES : CONVENTIONAL DEFINITION**

Adopters (n=51) *versus* potential and non-adopters (n=48)

Dependent variable: ***A binary variable: 1 for adopters and 0 for non-adopters & potential adopters***

Variable	Parameter estimate	Standard error	Wald Chi-square	Probability >Chi-square	Odds Ratio
CONTINUOUS VARIABLE					
Livestock income per LSU	0,003	0,009	10,014	0,0002	1,003
CATEGORICAL VARIABLES					
Roads	1,504	5,201	8,359	0,0038	4,499
Suppliers of livestock inputs/outputs	2,243	6,320	12,496	0,0004	9,422
Breeding technology	1,496	5,816	6,613	0,0101	4,462
Intercept	–3,274	7,660	18,268	0,0001	–
Percentage of farmers classified correctly (99)*					74,5%
Percentage of adopters classified correctly (51)*					74,5%
Percentage of potential and non-adopters classified correctly (48)*					74,5%

* Using a cut-off point of >0,05.

The results in Table 6.1 indicate that if a predicted probability of adoption of >0,5 is considered to define adoption, the model correctly classifies the adoption category of 74,5 per cent of the 99 farmers in the sample. This model classifies 74,5 per cent of adopters and also 74,5 per cent of the potential adopters and non-adopters (in one group) correctly.

In the conventional definition of adoption there are 52 per cent adopters who make use of veterinary surgeon services at least once a year and 48 per cent of the farmers who do not use these services. The total livestock income per LSU per year is the only continuous variable that contributes to the adoption of veterinary surgeon services. This variable is one of the most important measurements of livestock income of the small ruminant farmer (financial efficiency). Farmers with a higher total livestock income per LSU per year are more likely to make use of veterinary surgeon services. It is, however, important to realise that this relationship can be more complex than a simple cause/effect, as higher financial efficiency may be a predictor as well as a result of the use of this technology. The annual livestock income per LSU is R381 for the adopters, which is

significantly higher than R236 per LSU per year for the potential and non-adopters. It can therefore be deducted that the use of a veterinary surgeon increases total livestock income per LSU per year and *vice versa.*

The significance of breeding technology (usage of registered or grade rams), as a predictor of the adoption of veterinary surgeon services, is an indication that farmers making use of the more expensive rams, will be more inclined to use veterinary surgeon services. Adopters of breeding technology make significantly more use of veterinary services (70%) than the potential and non-adopters (53%). It is, however, important to realise that this relationship can, as in the case of annual livestock income per LSU, also be more complex than a simple cause/effect. The use of registered or grade rams may be a predictor as well as a result of the use of veterinary surgeon technology. Farmers with more expensive sires will tend to take better care of their animals. They will probably have a higher opportunity cost or incentives in using a veterinary surgeon when their animals become sick. The predictors "availability of roads" and "accessibility of input suppliers" also contribute to the adoption of veterinary surgeon services technology in this definition of adoption. These findings correspond with those of Mellor (1990:81), and are in agreement with the technology diffusion theory of Feder *et al.* (1985), Hayami and Ruttan (1985) and Wheeler and Ortmann (1990). For example, the significance of roads and input suppliers is an indication that the total support system needed for technology adoption is not well developed in Qwaqwa. If road infrastructure and institutions such as suppliers of livestock inputs were available and accessible to more farmers, the adoption level of veterinary surgeon services could have been much higher. These results also reflect the barrier effect of increased transportation costs on new technology adoption, as indicated in the model of Von Thünen (Barlowe, 1978).

In Qwaqwa, after the withdrawal of government paid state veterinary surgeons, the supply of veterinary surgeon services became very limited and non-adopters therefore less elastic. Sick animals have to be transported over long distances at relatively high costs[1] to private veterinary surgeon clinics, therefore the cost of veterinary surgeon services and

[1] Fully subsidised government veterinary surgeon services were available free of charge at the sheering sheds up to 1993. Only a private veterinary surgeon is at present available in Puthaditjhaba for three hours per week where transportation cost is up to R250 (100 km @ R2,50/km). When a farmer has to travel to Harrismith to the private veterinary clinic, the transportation cost doubles to R500 per trip.

medication information increase with a consequent decrease in demand for such technology (Figure 6.1). It can be assumed that farmers do not make more use of the new technology simply because of its relatively high costs or because the expected incentives of these technologies are perceived not to be cost-effective. The conceptualisation of the theoretical approach of the Von Thünen model of regional economics (Barlowe, 1978; O'Kelly, 1988) adapted to the situation in Qwaqwa is explained in Figure 6.1.

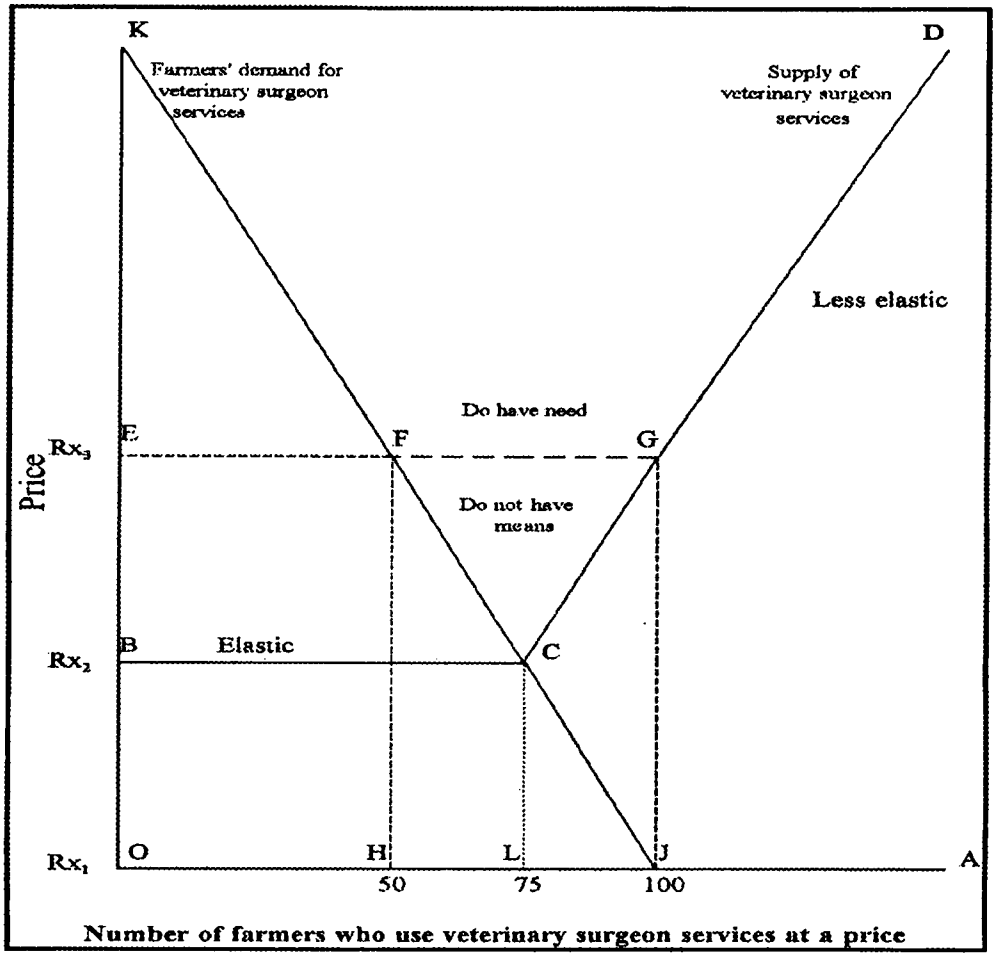

Figure 6.1: **Supply and demand of veterinary surgeon services in Qwaqwa**

Rx_1	Cost of government veterinary surgeon services was free (1993).
Rx_2	Cost of private veterinary surgeon services at Phuthaditjhaba in Qwaqwa. (Veterinary surgeon services cost + transport to Phuthaditjhaba.)
Rx_3	Cost of private veterinary surgeon services at Harrismith. $Rx_3 = Rx_2$ + transport costs from Phuthaditjhaba to Harrismith.
OA	Total number of small ruminant farmers.
OA	Elastic supply curve of government veterinary surgeon services: OJ Adopters JA Non-adopters.
BC	Elastic supply curve of veterinary surgeon services in Phuthaditjhaba for three hours per week. OL Adopters LJ Potential adopters JA Non-adopters.
CD	Less elastic supply curve of private veterinary surgeon services at Harrismith. OH Adopters HJ Potential adopters JA Non-adopters.
JK	Demand curve of farmers for veterinary surgeon services. If the incentive or economy of a technology increases, the demand curve will shift upwards and more farmers will become adopters and less potential adopters.

If farmers have to travel to obtain veterinary surgeon services (which leads to transport costs), it becomes a supply as well as a demand problem at a specific point. If a veterinary surgeon is stationed in Qwaqwa and paid by the government (like it was before 1994) and these services are available at no cost (Rx_1), a certain number of farmers will adopt (OJ) this technology and a lower number of farmers (JA) will not (non-adopters). When the government decided to withdraw veterinary surgeons from the sheering sheds and Qwaqwa, the only option was to use private veterinary surgeons who were available in Phuthaditjhaba at a price (Rx_2) for only three hours a week, which includes veterinary fees plus transport costs. At this cost the supply is elastic and the number of adopters reduce to OL, creating a number of would be or potential adopters (LJ), who can no longer afford such costs. In this case, potential adopters are those farmers who have the need for veterinary surgeon services but not the means to get hold of it. These farmers can be regarded as potential adopters as they would have been adopters at lower cost. Variables motivating the adoption decision may therefore be confused with those that indicate the ability to acquire the limited technology. If the farmers need veterinary assistance at any time during the three weekly hours the private veterinary surgeon is available in Phuthaditjhaba, they have to travel with their sick animals to Harrismith. In this case the total costs for obtaining the veterinary services at Harrismith are increasing to Rx_3 due to extra transport costs (Rx_3 - Rx_2). This increased cost (Rx_3) causes a further reduction on the number of adopters (to OH) and a consequent increase of potential adopters (to HJ).

The results of the model discussed above are done in the context where the assumption of an elastic supply of veterinary surgeon services is not violated (which is not the case in Qwaqwa). Therefore, some of the coefficients estimated are expected to be biased.

Table 6.2: **ADOPTION OF VETERINARY SURGEON SERVICES : ADAPTED DEFINITION**

Adopters & potential adopters (n=86) *versus* non-adopters (n=13)					
Dependent variable:	*A binary variable: 1 for adopters & potential adopters and 0 for non-adopters*				
Variables	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**	**Odds Ratio**
CONTINUOUS VARIABLES					
Farming efficiency	0,036	0,016	4,984	0,026	1,036
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	0,017	0,010	3,206	0,073	1,017
CATEGORICAL VARIABLES					
Breeding technology	1,528	0,743	4,229	0,040	4,610
Intercept	−1,282	0,0925	1,921	0,166	
Percentage of farmers classified correctly (99)*					83,7%
Percentage of adopters & potential adopters classified correctly (86)*					95,3%
Percentage of non-adopters classified correctly (13)*					0,0%

* Using a cut-off point of >0,05.

The results in Table 6.1 indicate that if a predicted probability of adoption and potential adoption of >0,5 is considered to define adoption and potential adoption, the model correctly classifies the adoption category of 83,7 per cent of the 99 farmers. The model correctly classifies 95,3 per cent of adopters and potential adopters (in one group). None of the non-adopters are correctly classified by this model. This, however, does not mean that the model cannot distinguish between adopters and potential adopters (in one group) *versus* non-adopters, but only that if a cutoff point of 0,5 is used, separation is not made. The adopters and potential adopters have a median predicted probability of being an adopter/potential adopter of 0,96, whereas the non-adopters have a median predicted probability of 0,72. Using a cutoff point of 0,9 would lead to 68,6 per cent of adopters and potential adopters, and 75 per cent of non-adopters being classified correctly.

In the second analysis the effect of scarcity or the lack of availability and accessibility of veterinary services is removed (Table 6.2). A logit model for the adoption of veterinary surgeon services technology was re-estimated under a broader (adapted) definition of

adoption. In this definition, adopters are not only farmers who actually adopted veterinary services, but also those farmers in the sample who would have used veterinary services had it been available and accessible (A & Pot/A: n=86) and non-adopters (N/A: n=13). Weaning percentage, one of the most important technical and economical efficiency parameters on small ruminant farming, was used to test farming efficiency since it reflects fertility, conception rate, lambing percentage and mortality rate (Greyling, 1998). The hypothesis is that more efficient farmers will be more likely to make use of veterinary surgeon services.

The empirical results indicate that from five possible predictors used to estimate this model, only two continuous variables (farming efficiency and type of farmer) and one categorical variable (breeding technology) contributes significantly to the adoption of veterinary surgeon services. These results correspond to the findings of Mellor (1990).

The variable type "farmer (sheep or goat farmer)" reveals that sheep farmers are more likely to be adopters and potential adopters of veterinary surgeon technology than goat farmers. In addition, those farmers who use the more expensive registered and grade rams that most probably result in a higher efficiency as well as a higher weaning percentage (Greyling, 1998), are more likely to use veterinary surgeons (A = 62%; Pot/A = 71%; N/A = 25%). These results reveal that the characteristics of potential adopters gravitate more to those of the adopters than to those of the non-adopters.

Both models identify breeding technology as a significant contributor (predictor) of adoption of veterinary surgeon services. This variable appears to be critical in the adoption/diffusion process under both scenarios of elastic and non-elastic supply of veterinary surgeon services. Farming efficiency (technical and economical) (adapted definition), and livestock income (financial) efficiency (conventional definition) are also highly significant predictors. These results also stress the importance of access to high quality breeding stock and information on the improvement of farming and financial efficiency and its contribution to adoption decisions.

In the past veterinary surgeons, livestock inspectors and extension officers visited the sheering sheds on a regular basis to examine sick animals and they also brought medication (at subsidised costs) with them. Farmers did not need roads to go to a veterinary surgeon or to get hold of veterinary drug suppliers, as it was brought to them. The significance of the variables "roads" and "supplier of veterinary inputs" with the conventional definition and not with the adapted definition, is an indication that if the supply of veterinary surgeon services were elastic, potential adopters could get veterinary surgeon services, and roads and suppliers of veterinary inputs would not have an influence on the adoption of this technology (like it was before 1994).

If the new policy introduced in Qwaqwa after 1994 regarding the agricultural extension services is to be maintained, this result suggests that the roads and transport network and institutions need to be improved in former homelands of South Africa.

6.3 CONCLUSIONS

The results discussed in this chapter indicate that the adapted definition of adoption presented a more accurate model of prediction than the conventional definition, as the characteristics of potential adopters gravitate more to adopters than to non-adopters. When the assumption of elastic supply of services or inputs, and increased transportation costs as a cause of the location of the farms is violated, potentially misleading conclusions can be made regarding the significance of variables that contribute to the prediction of the adoption of technologies based on the traditional definition of adoption, and make it difficult to clearly interpret the cause-effect-relationship between factors. In the conventional type of adoption studies farmers who would have adopted new technologies, will be classified as non-adopters. Restricted access to inputs or services in rural developing areas as well as the unavailability of roads, are major constraints for the farmers who wish to adopt new technologies that are not readily available or accessible. In future studies for these types of farmers, it is important to consider the use of the suggested adapted definition of adoption used in this chapter. If additional transport costs to the price of inputs or services are ignored, it may lead to policy recommendations that would not solve

the real problem to accelerate adoption and would concentrate on activities among those farmers who are already adopting new technologies. Instead, these recommendations must rather concentrate on the improvement of infrastructure or other ways to affect inputs or service prices with a less elastic supply, and increase the supply or access to information on new technologies and critical factors limiting adoption.

The radical change from 1994 in the government's policy on agricultural development in Qwaqwa, and the discontinuation of a locally stationed veterinary surgeon (subsidised by the government) who was available on a regular basis at the sheering sheds, seem to have contributed negatively to the use of veterinary surgeon services by the local farmers. Currently the poor road infrastructure, the difficult access to the inputs, outputs, services, information and the non-subsidised veterinary services provided by a private veterinary surgeon, is a major constraint to most of the potential adopters. The diffusion programmes in New Qwaqwa continued after 1994 through Agriqwa, but were suspended in Old Qwaqwa or handled by inexperienced extension officers. The explanation for this result is that the farmers in New Qwaqwa, who adopted veterinary surgeon services, started farming approximately nine years ago, and the farmers in Old Qwaqwa who want to adopt the technology have been farming for a longer period. Seventy-seven per cent of the potential adopters are from Old Qwaqwa.

The other section of livestock veterinary technology, namely medication technology usage, needs further attention. In Chapter 7 attention will be given to the transfer and adoption of four groups of medication as well as the determination of predictors contributing to the adoption of the different groups of medication.

Chapter 7

ADOPTION OF MEDICATION TECHNOLOGIES

7.1 INTRODUCTION

The correct usage of medication technologies is an important factor for the success of any livestock farming activity, as disease and high mortality are major constraints on livestock production in Southern Africa (McKinnon, 1985). In a survey done amongst commercial sheep farmers in the Northern Free State, North and North-Western Cape it was found that internal parasites, diseases and external parasites were the most important problems in sheep production systems (Joubert, Van Wyk & De Wet, 1994). They also found that these farmers regard internal parasites of which the effects are visible, as most important and react accordingly.

In the past the veterinary surgeon, as well as the extension and animal health officers in Qwaqwa, played an important role in the diffusion of livestock medication technologies. They regularly visited the sheering sheds where they supplied the farmers with medication remedies and vaccines recommended for that area, at a subsidised or reduced price. Farmers were also informed on the importance and correct use of prophylactic medication such as vaccines as well as its economical importance. Farmers regularly received instruction in the use and practical application of these medication technologies which enabled them to become independent. After being withdrawn from the area in 1994, these diffusion programmes came to a standstill.

Medication technologies in this study refer to the four major groups of medication (external and internal parasite remedies, antibiotics and vaccines) that are applied to small ruminants by farmers themselves. The correct usage (adoption) of such technologies by the farmers is the best measure to evaluate the efficiency of the livestock extension services and the role of other socio-economic factors in this adoption process.

The characteristics of the adoption groups and the identification of possible predictors (p-values $\leq 0,15$) for inclusion in the different models for each of the medication groups are presented in Annexure C. The next section of this chapter discusses, in four separate sections, the empirical results (significant predictors, p-values $\leq 0,15$, contributing to adoption) of the four medication groups. The chapter ends with conclusions on the adoption of medication technology by small ruminant farmers in Qwaqwa.

7.2 RESULTS AND DISCUSSION

In this section the empirical results of the different models are discussed.

7.2.1 External parasite remedies

For these remedies the dependent variables consisted of three categories, i.e. full adopters, partial adopters and over-adopters. Adopters of external parasite remedies were defined as follows:

- ***Full adopters*** (66) ***and over-adopters*** (18) (n = 84): Uses external parasite drugs twice or more per year to prevent scab and ticks.
- ***Partial adopters*** (n = 13): Uses external parasite drugs once a year to prevent scab and ticks .
- ***Wrong adopters*** (n = 2): Uses wrong remedies for external parasite control. This group was not considered in the model as two farmers are too few to be used as a group to allow any valid statistical analysis.

The characteristics of the adoption groups are presented by using the definition of full and over-adopters (F & O/A) and partial adopters (P/A) as given above. The fact that there are no non-adopters, is an indication that farmers have adapted to the use of this type of medication reasonably well. The high sales of external parasite drugs in Qwaqwa, according to Venter (1998), are underlined by the fact that there were only 13 partial adopters and 84 full and over-adopters.

The continuous variables (14), mean (age) and median (all continuous explanatory variables except age) characteristics of the farmers in the different adoption groups are summarised in Annexure C, Table C.3. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.4.

The results of the external parasite remedy adoption logit model are presented in Table 7.1. Of the nine possible predictors (age, family size, herd size, indebtedness, attitude towards risk, information sources [technical decisions], roads, local markets and mating seasons) used in the estimation of the logit model, six predictors (one continuous and five categorical variables) were retained in the final model (p-values $\leq 0,15$).

If a predicted probability for full and over-adoption of $>0,5$ is considered to define full and over-adoption, the model correctly classifies the adoption category of 81,4 per cent of the 97 farmers. This model correctly classifies 92,9 per cent of the full and over-adopters and 7,7 per cent of the partial adopters. This does not, however, mean that the model cannot distinguish between full and over-adopters *versus* partial adopters, but only that using the cutoff of 0,5 does not distinguish well between them. The full and over-adopters have a median predicted probability of being true full or over-adopters of 0.97, whereas the partial adopters have a median predicted probability of 0,71. Using a cutoff of 0,9 would lead to 65,5 per cent of full and over-adopters being classified correctly, and 76,9 per cent of partial adopters. It can therefore be stated that the model results can be used to explain the full or partial adoption of external parasite remedies.

Table 7.1: **ADOPTION OF EXTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS**

Full and over-adopters (n=84) *versus* partial adopters (n=13)

Dependent variable: A binary variable: 1 for full and over-adopters and 0 for partial adopters

Variable	Parameter estimate	Standard error	Wald Chi-square	Probability >Chi-square	Odds ratio
CONTINUOUS VARIABLE					
Age	-0,059	0,035	2,929	0,087	0,942
CATEGORICAL VARIABLES					
Risk-averse	-1,192	0,814	2,147	0,143	0,304
Technical decisions 2 - Co-farmers	2,323	1,583	2,152	0,142	10,201
Technical decisions 3 - extension services.	3,529	1,416	6,207	0,013	34,094
Infrastructure (local markets)	-0,677	0,301	5,071	0,024	0,508
Farmer making use of any of the four mating seasons	1,611	0,781	4,258	0,039	5,006
Intercept	4,571	2,372	3,713	0,054	-
Percentage of farmers classified correctly (n = 97)*					81,4%
Percentage of full and over-adopters classified correctly (n = 84)*					92,9%
Percentage of partial adopters classified correctly (n = 13)*					7,7%

* Using a cut-off point of >0,05.

Age is the first explanatory variable that emerges as a significant predictor. The mean age (55 years) of full and over-adopters is lower than that of the partial adopters (62 years). The negative coefficient of age indicates that older small ruminant farmers are less likely to adopt external parasite remedies in full. This finding is in agreement with the literature on diffusion that suggests that older farmers tend to be less likely to adopt new technologies at all or partly, than younger farmers (Feder, Just & Zilberman, 1985).

The next variable that emerges as a significant predictor of adoption of external parasite remedies is attitude towards risk (risk-averseness). Fifty-four per cent of the partial adopters are risk-averse in comparison to 24 per cent of the full and over-adopters. The negative coefficient of risk aversion indicates that farmers who are risk-averse are more likely to be only partial adopters of external parasite remedies, while those who are risk-

seeking tend to be full and over-adopters of this technology. This, however, does not mean that risk-averse farmers will not adopt external parasite remedies, but only that they are more cautious with regard to the cost side of these medications. It can be deducted from the question asked in the questionnaire that they try to protect their profit flow by only applying external parasite remedies when it is absolutely necessary (see section D7 of the questionnaire in Annexure A). This is in agreement with Cromie and O'Donaghue (1992) and Gibbons, De Koninck and Hasan (1980), who stated that the more creative farmer is more risk-seeking and more willing to adopt new technologies.

The information sources approached by farmers when they have to make technical decisions, is the next variable that emerges as a significant predictor. The following information sources were tested with this variable: extension sources, co-farmers, the media and own decisions (farmers taking decisions on their own without approaching any of the mentioned sources). Two sub-groups of this variable presented significant predictors, namely extension sources and co-farmers.

The positive coefficients of extension services and of co–farmers as information sources when technical decisions have to be made are an indication that farmers who make use of these sources, are more likely to be full and over-adopters of external parasite remedies, than those who use the media and their own knowledge. Eighty-three per cent of the full and over-adopters approach extension sources when they have to make technical decisions, in comparison to 62 per cent of the partial adopters. Co-farmers as an information source, are approached by 15 per cent of the partial adopters. Extension services as information source, however, have a much greater contribution to adoption of external parasite remedies than co-farmers, as can be seen from their odds-ratio of 34,1 and 10,2 respectively. This is an indication that the need for extension advice is there, but that the extension services are not functioning efficiently in Qwaqwa. The significance of co-farmers as information source when technical decisions have to be made, is an indication that co-farmers also play an active role when it comes to technology diffusion (farmer to farmer diffusion). Some farmers have the means to make contact with extension services; others make use of the help of co-farmers. According to Von Thünen's theory, it is cheaper for farmers to attain information from co-farmers due to

their closeness, than to pay additional transport costs to contact extension sources. The positive coefficient of extension sources approached when technical decisions are made, is an interesting result as extension visits as a variable did not emerge as a significant predictor of adoption in this study. This variable was also considered an important predictor of adoption of new technologies in other studies (Mijindadi, 1995; Swanepoel & Darroch, 1991; Wellard & Copestake, 1993).

The negative coefficient of infrastructure (i.e. the availability and accessibility of local markets) is an indication that when local markets are more available and accessible to small ruminant farmers, they tend to adopt external parasite remedies only partially and that it would be less likely for them to be full or over-adopters of external parasite remedies. A possible reason for the negative sign may be that farmers who are more close to the markets are speculating with small ruminants. Speculators, other than small ruminant farmers, will not spend on medication if they know that they will be selling their animals, particularly if the price will not be affected by the presence of ecto-parasites.

The use of mating seasons as a predictor, contributes significantly to full and over-adoption of external parasite remedies. This is an indication that the more efficient farmers (those with higher management skills) will be more likely to use external parasite remedies, probably because they are also more informed about the advantage of such technologies, and therefore they tend to be more careful about the health status of their small ruminant herds. The use of breeding seasons and improved sires for breeding is a sign of maturity of the management skills of farmers and the adoption of basic management and breeding principles with the aim of improving small ruminant productivity. It was therefore expected that farmers adopting "sophisticated" breeding/management techniques would have adopted basic techniques such as the use of external parasite remedies. The use of mating seasons results in short lambing/kidding seasons that facilitate the management and the adoption of a dipping programme, as all the lambs/kidds are the same age at any given time.

7.2.2 Internal parasite remedies

The adoption of internal parasite remedies was broken down into three categories, i.e. full adopters, partial adopters and over-adopters. A multinomial logit model is the most appropriate model to use (see Chapter 3 & Annexure B), as more than two categories of adoption are identified. Adopters of internal parasite remedies were defined as follows:

- ***Full adopter*** (n = 12): Uses remedies against roundworms four to six times, tapeworms two to four times and nasal worms more than once a year.
- ***Partial adopter*** (n = 70): Uses less than the defined levels for a full adopter in any of the groups.
- ***Over-adopter*** (n = 15): Uses remedies against roundworms, tapeworms and nasal worms more than the defined times per year in any of the groups.
- ***Non-adopter*** (N/A) (n = 2): Uses no remedies for internal parasites. This group was not considered in the model as it would not render valid statistical results.

In a multinomial logit model all variables identified as possible predictors (p-value $\leq 0,15$) in pairwise comparison between the groups, must be included in the model. In this case, 19 possible predictors must be included in the multinomial logit model. However, the numbers in the groups of two of the three adoption groups used (full adopters and over-adopters), are less than the possible predictors (19 variables) to be included in the model. A result can therefore not be reached because of zero degrees of freedom. Two standard logit models were therefore used to determine predictors of adoption of internal parasite remedies, using one dependent variable (partial adopters) chosen beforehand as a base group. A multinomial logit model for internal parasite remedies was then fitted using the seven predictors attained from the two standard logit models fitted (full adopters *versus* partial adopters and over-adopters *versus* partial adopters) as possible predictors.

The characteristics of the variables studied for the different adoption groups are presented by using the definitions of partial adopters, full adopters and over-adopters as given earlier. The presence of only two non-adopters is an indication that farmers in general have adopted the use of this type of medication reasonably well.

The mean and median characteristics of the 14 continuous variables of the farmers in the different adoption groups, are summarised in Annexure C, Table C.5. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.6.

The results of the first internal parasite remedy adoption logit model (**full adopters *versus* partial adopters**) are presented in Table 7.2. Of the eight possible predictors (age, education level, mortality rate, extension officer visits, type of farmers, attitude towards risk, financial management and transport) used in the estimation of the first logit model, four predictors (two continuous and two categorical) were significant (p-values $\leq 0,15$) and were therefore retained in the final model as predictors.

Table 7.2: **ADOPTION OF INTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS - FULL *VERSUS* PARTIAL ADOPTERS**

Full adopters (n=12) *versus* partial adopters (n=70)					
Dependent variable: A binary variable: 1 for full adopters and 0 for partial adopters					
Variables	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-Square**	**Odds ratio**
CONTINUOUS VARIABLES					
Age	0,088	0,040	4,831	0,028	1,092
Type of farmer (Sheep livestock units (LSU's) as percentage of small ruminant LSU's)	0,038	0,020	3,691	0,055	1,039
CATEGORICAL VARIABLES					
Risk d2 – Averse	–2,286	1,172	3,804	0,051	0,102
Financial management	1,090	0,735	2,198	0,138	2,973
Intercept	–10,281	3,755	7,495	0,006	–
Percentage of farmers classified correctly (n = 82)*					82,9%
Percentage of full adopters classified correctly (n = 12)*					8,3%
Percentage of partial adopters classified correctly (n = 70)*					95,7%

* Using a cut-off point of >0,05.

In the first model where variables distinguishing between **full and partial adopters** were estimated, four variables (two continuous and two categorical variables) emerged as predictors contributing to the full adoption of internal parasite remedies.

If a predicted probability for full adoption of >0,5 is considered to define full adoption, the model correctly classifies the adoption category of 82,9 per cent of the 82 farmers. The model correctly classifies 95,7 per cent of the partial adopters and 8,3 per cent of the full adopters.

Age contributes positively to the full adoption of internal parasite remedies. Full adopters tend to be older (63 years) than over-adopters (55 years) and partial adopters (54 years). The positive coefficient of age in the internal parasite model is an indication that older small ruminant farmers will be more likely to be full adopters (i.e. applying a recommended programme) of internal parasite remedies than younger farmers. This result is contradictory to that of external parasite remedies (applying a recommended deworming programme). A possible explanation for this contradiction is that it is relatively more difficult to identify (diagnose) small ruminants affected by internal parasites and to treat them correctly (application of internal parasite remedies), compared to the case of external parasite infestations. The correct adoption of internal parasite remedies requires more experience than external parasite remedies, which often comes with age.

Type of farmer (sheep as percentage of the total small ruminant herd) contributes significantly as a predictor of full adoption of internal parasite remedies. Full adopters have a median percentage of 100 per cent sheep (mean 87%) in their small ruminant herds, partial adopters 75 per cent and over-adopters 54 per cent, which is an indication that full adopter farmers tend to have more sheep in their herds than partial and over-adopters. Thus, sheep farmers tend to use internal parasite remedies more correctly than goat farmers. This result emphasises that sheep farmers are more likely to be adopters of internal parasite medication than goat farmers, as sheep are more susceptible to internal parasites than goats (Kriek, Odendaal & Hunter, 1994).

Attitude towards risk (risk-averseness) emerges as a significant predictor of adoption **in all the fitted models** on internal parasite remedies. Of the partial adopters 36 per cent are risk-averse, in comparison to eight per cent of the full adopters and seven per cent of the over-adopters. As in the case of external parasite remedies, the negative coefficient of risk aversion indicates that farmers who are risk-averse are more likely to be only partial adopters of internal parasite remedies, while those who are risk-seeking[1] tend to be full or over-adopters of this technology. This, however, does not mean that risk-averse farmers will not adopt internal parasite remedies, but only that they are more cautious with regard to the cost of these remedies. The conclusion can be drawn that they try to protect their profit flow by only applying internal parasite remedies when it is absolutely necessary (see question D7 in the questionnaire in Annexure A).

All the models indicate that financial management contributes positively to full and over-adoption of internal parasite remedies. Full adopters (92%) are keeping significantly better financial records than over-adopters (80%), who also tend to keep better records than partial adopters (60%). If keeping financial records is an indication of better management practices, then it can be said that the better the financial management level, the more likely the probability that farmers will use internal parasite remedies correctly. The probable reason may well be because they can better realise the financial advantage (cost/benefit ratio) of using (adopting) this technology.

The results of the second internal parasite remedy adoption logit model (**over-adopters *versus* partial adopters**) are presented in Table 7.3. Of the 11 possible predictors (level of entrepreneurship, total livestock income per LSU, herd size, type of farmer, reasons for farming, attitude towards risk, financial management, institutions [government and cooperative extension and agricultural research, suppliers of inputs/outputs], location of farmer in Qwaqwa and breeding technology) used in the estimation of the second logit model, five predictors (two continuous and three categorical) were significant (p-values $\leq 0,15$) and were therefore retained in the final considered model.

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[1] Risk-seeking was used as base dummy variable.

Table 7.3: **ADOPTION OF INTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS - OVER *VERSUS* PARTIAL ADOPTERS**

Over-adopters (n=14) *versus* partial adopters (n=70)					
Dependent variable: A binary variable: 1 for over-adopters and 0 for partial adopters					
Variables	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-Square**	**Odds Ratio**
CONTINUOUS VARIABLES					
Total livestock income per LSU	0,0016	0,0009	3,093	0,079	1,002
Reasons for farming	–0,405	0,265	2,346	0,126	0,667
CATEGORICAL VARIABLES					
Risk d2 – Averse	–2,082	1,138	3,351	0,067	0,125
Financial management	1,039	0,717	2,098	0,148	2,826
Suppliers of inputs/outputs	–2,088	1,131	3,407	0,065	0,124
Intercept	–1,308	0,820	2,542	0,111	–
Percentage of farmers classified correctly (n = 84)*					84,5%
Percentage of over-adopters classified correctly (n = 14)*					28,6%
Percentage of partial adopters classified correctly (n = 70)*					95,7%

* Using a cut-off point of >0,05.

In the second model where variables differentiating between **over and partial adopters** were identified, five variables (two continuous and three categorical) were significant. The variables "risk" and "financial management" are discussed under the previous model, as similar coefficients were obtained and the same reasoning is valid for the two logit models of adoption of internal parasite remedies.

If a predicted probability for over-adoption of >0,5 is considered, the model correctly classifies the adoption category of 84,5 per cent of the 84 farmers. This model correctly classifies 95,7 per cent of the partial adopters and 28,6 per cent of the over-adopters.

An interesting result is that total annual livestock income per LSU of over-adopters (R493 per year) tends to be higher than that of the partial adopters (R282 per year). This result indicates that higher financial efficiency generates a higher capacity to buy internal parasite remedies which are generally more expensive, or that there is in fact a need for a more intensive internal parasite control, than recommended for full adoption. If this is the case, it may be an indication of internal parasite resistance against some internal parasite remedies used, which forces farmers to use different remedies more frequently than recommended, as some treatments might be ineffective (Schwalbach, 1998). The low mortality rates reported does not, however, suggest that either of these probabilities are relevant. So it can be generalised that the adoption of internal parasite remedies is related to higher financial efficiency.

Farming for normal (commercial) reasons contributes negatively to over-adoption and favours the partial adoption of internal parasite remedies. Farmers were asked to rate the importance of keeping small ruminants for normal farming purposes from very important to not important. Partial adopters rated it as important, while full adopters rated it as less important to important and over-adopters as unimportant, which indicates that over-adopters see the keeping of small ruminants for commercial purposes as not important, while full adopters see it as relatively important. This result is in direct contradiction to that of the previous variable (i.e. livestock income per LSU per year). This question was perhaps not stated or understood correctly. From the results in Chapter 5, it was concluded that small ruminant farmers in Qwaqwa are mainly commercially orientated, selling about 70 to 80 per cent of their products. Farming for own consumption and for cultural reasons were in general rated less important. A considerable part of these farmers rated farming for investment and for a source of money (which are also commercial reasons) as very important. From these results it can be assumed that farmers tend to be mainly commercially orientated. Farming for a source of easy convertible money is a common characteristic in most African livestock production systems (Diomisio, 1985). Banks are usually located in urban areas, far from the farmers, and a less viable option for farmers to keep savings due to increased transaction costs (transport), than withdrawing

their savings. This is a possible reason why farming for investment was rated so high by the local farmers.

The availability and accessibility of input/output suppliers and banking services are negatively related to over-adoption of internal parasite remedies and favour partial adoption. Input/output suppliers and banking services are significantly more available and accessible to partial adopters of internal parasite remedies (40%), than to over-adopters (7%). These results imply that if more input/output suppliers are available and accessible, more advice and information on the use of internal parasite remedies can be provided. Farmers will tend to use this expensive medication more efficiently and would be more likely to become partial adopters rather than over-adopters. These results also support the findings of Finlayson (1995) who stated that cost and quality of information have an influence on the level of adoption of new technologies.

The presence of only two non-adopters of internal parasite remedies is an indication that farmers have adopted the use of this type of medication reasonably well. However, the low percentage of full adopters and the absence of a significant contribution of extension visits in the models of adoption of this medication technology is an indication that farmers in Qwaqwa are aware of this technology, but are not using it correctly due to inefficient technology transfer (extension).

A multinomial logit model was fitted, using the significant predictors of the two standard logit models as possible predictors of adoption of internal parasite remedies (age, type of farmer, risk, financial management, total livestock income per LSU, reasons of farming and suppliers of inputs) as discussed earlier. The results are presented in Table 7.4.

Table 7.4: **ADOPTION OF INTERNAL PARASITE REMEDIES: MULTINOMIAL LOGIT MODEL RESULTS**

Full adopters (12) *versus* Partial adopters (n=70) and Over-adopters (n=14) *versus* Partial adopters (n=70)

Dependent variable: A binary variable: 1 for full adopters and 0 for partial adopters and A binary variable: 1 for over-adopters and 0 for partial adopters

Variable		Parameter estimate	Standard error	Wald Chi-square	Probability >Chi-square
CONTINUOUS VARIABLES					
Age	F/A	0,101	0,045	4,95	0,026
	O/A	0,007	0,022	0,10	0,755
Type of farmer	F/A	0,047	0,023	4,21	0,040
	O/A	-0,011	0,011	0,93	0,334
Total livestock income per LSU	F/A	-0,002	0,001	1,08	0,298
	O/A	0,002	0,001	3,08	0,079
Reasons of farming	F/A	0,007	0,289	0,00	0,981
	O/A	-0,386	0,277	1,94	0,163
CATEGORICAL VARIABLES					
Risk-averse	F/A	-1,118	0,583	3,68	0,055
	O/A	-1,047	0,564	3,45	0,063
Financial management	F/A	0,680	0,399	2,91	0,088
	O/A	0,536	0,362	2,20	0,138
Suppliers of inputs/outputs	F/A	-0,395	0,435	0,83	0,363
	O/A	-0,921	0,573	2,58	0,108
Intercept	F/A	-11,920	4,157	8,22	0,004
	O/A	-2,565	1,610	2,54	0,111

Of the seven possible predictors included into the multinomial logit model, six were significant. With the exception of reasons for farming with small ruminants, all the other variables showed similar results to those of the standard logit models. The results of the multinomial logit model are similar to those of the standard logit models and therefore the significant variables (predictors) will be discussed only once. The value of the multinomial logit model is that the results of the two logit models are confirmed

7.2.3 Antibiotics

The adoption of antibiotics can be broken down into, full adopters, partial adopters and non-adopters. Adopters of antibiotics were defined as follows:

- ***Full adopter*** (n = 16): Uses both systemic and local antibiotics to treat sick animals.
- ***Partial adopter*** (n = 69): Uses only either systemic or local antibiotics, but not both.
- ***Non-adopter*** (n = 14): Uses no antibiotics to treat sick animals.

Like with the internal parasite remedies, a multinomial logit model was regarded as the most appropriate discrete choice model to use. However, one of the three categories of adoption (the full adopters) had complete separation[2] in three possible predictors, which means that the multinomial logit model cannot be fitted with the variables Old and New Qwaqwa, indebtedness and transport. Excluding the three variables from the model will give misleading results.

The mean and median characteristics of the 14 continuous variables of the farmers in the different adoption groups are summarised in Annexure C, Table C.7. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.8.

The results of the logit model on the adoption of antibiotics are presented in Table 7.5. Of the 10 possible predictors (family size, mortality rate, indebtedness, extension officer visits, type of farmer, reasons for farming, training sources on medication usage, information sources approached for financial decisions, roads and location of farmers in Old Qwaqwa) used in the estimation of the logit model, four predictors (two continuous and two categorical) were retained in the final model (p-values $\leq 0,15$).

[2] This is when one of the categories or groups has a count of zero or 100 per cent.

Table 7.5: ADOPTION OF ANTIBIOTICS: LOGIT MODEL RESULTS - PARTIAL *VERSUS* NON-ADOPTERS					
Partial adopters (n=69) *versus* non-adopters (n=14)					
Dependent variable: A binary variable: 1 for partial adopters and 0 for non-adopters					
Variable	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**	**Odds ratio**
CONTINUOUS VARIABLES					
Family size	0,343	0,154	4,990	0,026	1,410
Mortality rate in 1997	1,910	1,082	3,113	0,078	6,750
CATEGORICAL VARIABLES					
Financial decisions - Co-farmers	-2,097	1,069	3,848	0,050	0,123
Roads	1,349	0,883	2,334	0,127	3,854
Intercept	-1,264	0,972	1,692	0,193	-
Percentage of farmers classified correctly (n = 83)*					79,5%
Percentage of partial adopters classified correctly (n = 69)*					92,8%
Percentage of non-adopters classified correctly (n = 14)*					14,3%

* Using a cut-off point of >0,05.

If a predicted probability of partial adoption of >0,5 is considered to define partial adoption, the model correctly classifies the adoption category of 97,5 per cent of the 83 farmers. The model correctly classifies 92,8 per cent of the partial adopters and 14,3 per cent of the non-adopters.

The median family size of partial adopters (seven) is larger than that of non-adopters (six). The positive coefficient of family size indicates that larger families as a predictor contributes significantly to the partial adoption of antibiotic technology. Balyamujura (1995) found that the larger "African" families are also more wealthy, which is the reason why larger families tend to be partial adopters rather than non-adopters. Larger families would probably have more sources of (spendable) income that can be used for the purchase of antibiotics that are the most expensive of the four types of medication studied.

Mortality rates (in 1997) of the full adopters (mean = 2,57%) was higher than that of the partial adopters (mean = 1,15%) and non-adopters (mean = 0,16%). The positive coefficient of mortality rates in the antibiotic logit model indicates that higher mortality rates will influence (motivate) farmers to use antibiotics. This is a logical result in the sense that non-adopters do not see the need for antibiotics because the mortality rate on their small ruminant herds is insignificant. It is, however, important to stress that the mortality rates reported by the local farmers in general are extremely low, particularly for this type of farming system. A possible reason for this can be the severe snowfalls in Qwaqwa in 1996 during which very high mortality rates were reported and only the strongest animals survived. Mortality rates of up to 33 per cent were reported by McKinnon (1985) for the same type of farmers in the south of Mozambique. However, the fact that significantly higher mortality rates are observed amongst farmers that use antibiotics reinforces the need to prevent rather than to cure diseases, relying on the efficiency of expensive antibiotics. On the other hand, farmers with significantly lower, in fact insignificant levels of mortality (0,16%) do not really have the necessity to treat animal sickness, as they do not cause significant losses in terms of mortality.

The negative coefficient of sources (co-farmers) approached when financial decisions are made indicates that farmers who use co-farmers as information sources to make financial decisions, tend not to use antibiotics on their herds. This is a clear indication that there is a need for more information and extension services in Qwaqwa. Twenty-one per cent of the non-adopters of antibiotics use the help of co-farmers when they make financial decisions, against 19 per cent of the full adopters and four per cent of the partial adopters.

The positive coefficient of roads as a predictor indicates that the availability and accessibility of roads positively contribute to the partial adoption of antibiotics. Full (63%) and partial (46%) adopters have a significantly better availability and accessibility to roads than the non-adopters (14%). This may indicate that farmers with access to roads prefer the use of antibiotics to treat their sick animals, than the use of vaccination to prevent diseases. When animals become sick, these farmers buy an antibiotic to treat them, but do not spend money on prophylactic vaccination. This result coincides with the result of veterinary surgeon services under the conventional definition of adoption as well as the barrier of increased transportation costs on technology adoption, as indicated by the

model of Von Thünen (Barlowe, 1978). Erasmus (1998) stated that livestock farmers in the former homelands react on what they see when it comes to the use of medication technologies and still prefer treatment to prevent livestock diseases.

7.2.4 Vaccines

For this remedy the dependent variable consisted of only two categories of vaccine adoption, namely partial adopters and non-adopters. Adopters of vaccines were defined as follows:

- ***Partial adopters*** (n = 82): Uses vaccination annually but not all the minimum recommended vaccinations to prevent diseases.
- ***Non-adopters*** (n = 17): Uses no vaccination at all to prevent diseases.
- ***Full adopters*** (n = 0): Uses all the minimum recommended vaccination – pulpy kidney twice a year, blue tongue and black quarter once a year – to prevent diseases.

Partial adopters were compared with non-adopters in an analysis to identify the variables (predictors) contributing to the adoption of vaccines.

The fact that there are no full adopters of vaccine technology, but only partial and non-adopters, is an indication that the level of adoption of this technology is quite low in Qwaqwa. It also indicates that the diffusion of vaccination technology was not efficiently done in the past. The withdrawal of veterinarians, competent extensionists and animal health officers of the Department of Agriculture from Qwaqwa after 1994, affected the efficiency and quality of the extension services. This, associated with the poor accessibility of veterinary surgeons and suppliers of curative remedies, had a negative impact on the adoption and usage of vaccination technologies by the local farmers. This finding is emphasised by the fact that according to Agri-Mark's yearly sales figures (Venter, 1998), the profit margins and the volume of sales of vaccines by the existing suppliers of inputs in Phuthaditjhaba have the lowest value of all four types of medication studied. Furthermore, it is not in the best interest of suppliers of therapeutic drugs (with higher profit margins than vaccines) to advocate the use of efficient prophylactic programmes that will reduce the sale of medicine for the cure of diseases. On the other hand, the mortality rate (real or perceived by the farmers) is very low. This aspect also has a very negative effect on the adoption of a disease prevention programme, as the cost-

effectiveness of such intervention will not be easily realised by the local farmers that keep very poor financial records. According to Erasmus (1998), livestock farmers in the former homelands react on what they see when it comes to adoption of medication for livestock production. Farmers prefer to treat rather than to prevent diseases. This means that vaccines are perceived by the local farmers as the least important group of medication. This is also one of the reasons why the adoption of this group of medication is so poor.

The 14 continuous variables, mean and median characteristics of the farmers in the different adoption groups are summarised in Annexure C, Table C.9. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.10.

The results of the vaccination adoption logit model are presented in Table 7.6. Of the seven possible predictors (herd size, indebtedness, type of farmer, reasons for farming, information sources approached for financial decisions, transport and location of farmers in Old Qwaqwa) in the estimation of the logit model, four predictors (two continuous and two categorical) were retained in the final considered model (p-values $\leq 0,15$).

Table 7.6: **ADOPTION OF VACCINES: LOGIT MODEL RESULTS - PARTIAL *VERSUS* NON-ADOPTERS**

Partial adopters (n=82) *versus* non-adopters (n=17)					
Dependent variable: A binary variable: 1 for partial adopters and 0 for non-adopters					
Variable	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**	**Odds Ratio**
CONTINUOUS VARIABLES					
Herd size (median number of small ruminant herd)	0,0110	0,007	2,674	0,102	1,011
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	0,0251	0,009	8,324	0,004	1,025
CATEGORICAL VARIABLES					
Information sources approached for financial decisions - Extension sources	1,207	0,726	2,762	0,097	3,343
Transport	-1,453	0,724	4,025	0,045	0,234
Intercept	-0,754	0,803	0,880	0,783	–
Percentage of farmers classified correctly (n = 99)*					86,7%
Percentage of partial adopters classified correctly (n = 82)*					95,1%
Percentage of non-adopters classified correctly (n = 17)*					43,8%

* Using a cut-off point of >0,05.

If a predicted probability of partial adoption of >0,5 is considered to define partial adoption, the model correctly classifies the adoption category of 86,7 per cent of the 99 farmers. This model correctly classifies 95,1 per cent of partial adopters and 43,8 per cent of the non-adopters.

The first variable that emerges as a significant predictor contributing to partial adoption of vaccines, is herd size. The positive coefficient of herd size is an indication that as herd size increases, the partial adoption of vaccines also increases. The median herd size of the 73 partial adopters tends to be higher than that of the 44 non-adopters. The fixed cost part of transaction costs of vaccination usage is generally aiming at groups in the herd or the whole flock. Transaction cost (transport is the major cost item of transaction cost in this study) normally decreases per unit treated, which makes this practice more economical for larger herds. Another reason for these farmers for partially adopting vaccines, may be the fact that vaccines often come in large packages (50 to 100 doses) and has an extremely short life once opened (Hunter, 1993). Larger farmers will use a higher proportion of the vaccine bottles and have less wastage than smaller farmers, which also reduces the cost per animal vaccinated.

The results of the type of small ruminant farmers show that partial adopters of vaccines have a higher percentage of sheep in their small ruminant herds (86%) in comparison with non-adopters who have only 46 per cent sheep in their small ruminant herds. The positive coefficient of sheep LSU's as percentage of small ruminant LSU's is an indication that the higher the percentage of sheep in a small ruminant herd, the higher the probability that the farmer will adopt vaccination technology. These results also indicate that sheep farmers are more likely to adopt vaccine technology than goat farmers, which corresponds with the result of veterinary surgeon services and internal parasite remedies. This may indicate that the use of vaccines in order to prevent diseases is more important for sheep than for goats, or that sheep are in general more susceptible to diseases than goats. In fact, pulpy kidney, one of the three disease in South Africa for which preventive vaccination was considered in this adoption category, infects sheep much more frequently than goats (Kriek *et al.*, 1994).

The information sources approached when farmers have to make financial decisions was broken down into the following groups: extension sources, co-farmers, the media and farmers taking decisions on their own with their family, without approaching any of the other mentioned sources. Only 23 per cent non-adopters of vaccination make use of extension sources when a financial decision has to be made, *versus* 49 per cent of the partial adopters. Twenty-four per cent of the non-adopters use co-farmers *versus* the six per cent partial adopters. This result indicates that partial adopters of vaccination tend to make more use of extension sources for financial decisions than non-adopters who consult co-farmers in this respect. Extension sources used to make financial decisions contributes positively to the adoption of vaccines. Even though extension visits did not emerge as a possible predictor, farmers have the need to approach extension sources when they need to make financial decisions.

Transport as infrastructure is accessible or available to only nine per cent of the partial adopters, in comparison with the 35 per cent non-adopters. According to the negative coefficient of transport in the model the better availability of transport contributes negatively to partial adoption of vaccine technologies in Qwaqwa. Farmers closer to input or service centres have an easier access to the suppliers of antibiotics and to the veterinary surgeon when needed. On the other hand, farmers with less access to transport are more pressured to adopt prophylactic measures to prevent diseases and use more vaccines. This means that in practice farmers with access to transport will argue that it is not that necessary to apply prophylactic measures on a small ruminant herd, because when an animal gets sick transport is available to take this animal to the veterinary surgeon or to buy remedies. This hypothesis is supported by the fact that roads as infrastructure were significant with a positive coefficient in the adoption models of veterinary surgeon services and antibiotics. This attitude can have far-reaching negative economic effects on the local small ruminant farming community, as preventative measures (vaccination) are far more economical than the treatment of most animal diseases.

If the availability and accessibility of informed and experienced extension sources in Qwaqwa increase, it is expected that the adoption of vaccination technology will also increase. This in turn will increase the profitability of the small ruminant herds and the sustainability of such production systems.

7.3 CONCLUSIONS

The results of this chapter indicate that there is a considerable difference of the variables (predictors) contributing to the adoption of the different medication technologies. The grouping of medication technologies is therefore essential if research on the characteristics of farmers adopting these different technologies have to be determined. The large variety of predictors in the different models is an indication that the high number of variables (34) considered was also a good decision.

The fact that there were no non-adopters and only two wrong adopters of external parasite remedies in the sample of 99 farmers, is an indication that diffusion programmes in Qwaqwa were effectively done in the past. The number of partial adopters of external parasite remedies (13), full adopters (66) and over-adopters (18), with a lack of a significant effect of extension visits, but with a significant effect of extension sources approached when technical decisions must be made by the farmers, are an indication that the government must pay more attention to diffusion programmes in livestock technologies in general and to external parasite remedies in particular. Continuous training on new developments and the correct number of applications of medication remedies are essential, as a disadvantage of partial adoption of external parasite remedies is that it can cause parasite resistance to these drugs and the spreading of resistant scab to full adopter farmers. This may increase the over-adoption and have an economical or financial implication for the whole farming community. Farmers who over-adopt external parasite remedies are wasting money on the unnecessary application of external parasite remedies, that could have been more efficiently used on the adoption of other medication technologies. The results in this chapter also reveal that full and over-adopters of external parasite remedies are younger, more risk-seeking, use extension sources when making technical decisions, and make more use of mating seasons.

The same trend occurs in the internal parasite remedy group of medication, where there were only two per cent non-adopters, 71 per cent partial adopters, only 12 per cent full adopters and 14 per cent over-adopters. This also reveals that farmers are aware of the usage of internal parasite remedies, which was transferred more efficiently before 1994.

However, farmers show a lack of knowledge on the correct frequency of application of these drugs, and on the need to use specific dewormers for different internal parasite infestations. This is a result of the insufficient visits of extension officers to the farms and to the sheering sheds after the restructuring of the Department of Agriculture. Adoption of internal parasite remedies relates to higher financial efficiency (livestock income per LSU per year), which stresses the importance of the correct adoption of this technology.

The results of the first two groups of drugs underlies the theory of Von Thünen (Barlowe, 1978) in the sense that when the subsidised medication services and information were withdrawn from the sheering sheds (Old Qwaqwa) and the farmer days (New Qwaqwa), it became too expensive for the farmers to attain the necessary information on the correct usage of these technologies. The negative coefficient of risk aversion, in both the external and internal parasite remedy models, indicates that farmers who are risk-averse are more likely to be only partial adopters, while those who are risk-seeking tend to be full and over-adopters of these two medication groups. This, however, does not mean that risk-averse farmers will not adopt these remedies, but only that they are more cautious when spending money on these medication. They try to protect their profit flow by only applying these remedies when it is absolutely necessary.

Roads (and not extension visits) in the antibiotic model are perhaps the most important aspect to consider. Antibiotics are no longer available at the sheering sheds, but they are urgently needed when an animal is already sick and the farmer need the medication as soon as possible to prevent mortality. The availability and accessibility of roads then become the main predictor of adoption of this technology. Higher mortality rates are also an incentive contributing to the adoption of antibiotics by small ruminant farmers in Qwaqwa.

Vaccination technology showed the lowest adoption level of all four medication groups studied, which also reflects the consequence of the changed policy with regard to the extension services by the government after 1994 when veterinary surgeons, experienced extension and animal health officers of the Department of Agriculture were withdrawn from Qwaqwa. Larger herds and a higher percentage of sheep in the herd are important contributors to the adoption of vaccine technologies by the small ruminant farmers in

Qwaqwa. In fact, sheep farmers are more likely to use veterinary surgeon services, internal parasite remedies and vaccines, as they are more susceptible to disease than goats.

The importance of transaction costs (mainly transport cost in the case of Qwaqwa) and the finding of Erasmus (1998), that former homeland farmers react on what they see when it comes to medication technology adoption and are therefore more likely to adopt therapeutic (treatment) technologies (external, internal remedies and antibiotics), rather than prophylactic (prevention) medication vaccines, became evident throughout this chapter. The lack of extension visits as a predictor of medication adoption is an indication that a very important determinant of technology transfer in other studies does not feature in this chapter on medication technology transfer and adoption. However, extension services are still approached by farmers that have to travel and pay transport costs to contact the extension officers. These aspects are very important to consider in future policy structuring on agricultural development.

These results suggest the need to reintroduce the services supplied before 1994 and to develop the basic infrastructure and institutions (roads, transport, banks, suppliers of inputs, etc.) if the government is serious in uplifting the level of rural agriculture in the former homelands. This aspect accounts for subsistence as well as commercial farmers in rural agricultural areas. The restoration of veterinary surgeon services and experienced extension officers in the former homelands in the rural areas of South Africa must be a government priority, aiming at agricultural and rural development.

Chapter 8

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 SUMMARY

During the literature study it became evident that there is ample literature available on crop technology transfer and adoption, but that research done on livestock technology transfer and adoption is rather scarce. To overcome this barrier it was decided to construct a panel of livestock veterinary specialists, consisting of veterinarians, animal scientists and extension officers (some from former Qwaqwa), to assist with the defining of the different categories of adoption and also the identification of variables that may contribute to the adoption of livestock veterinary technologies.

In this study possible predictors for the adoption of livestock veterinary technologies were identified by means of presenting significant differences (p-values $\leq 0,15$) between the various adoption groups and then fitted into logit models. Seven logit models were fitted for the different adoption groups of veterinary surgeon services, external and internal parasite remedies, antibiotics and vaccine technologies and an additional multinomial logit model was fitted for internal parasite remedies, using the predictors of the previous logit models for internal parasite remedies as possible predictors. The results of the multinomial logit model were similar to those of the two logit models. Only the results of the logit model will therefore be discussed.

A summary of the significant variables of each of the seven logit models (two for veterinary surgeon services and five for the four medication groups) with their respective parameters and chi-square values, are presented in Table 8.1. The significant variables of each adoption model with their respective coefficients and chi-square values are also presented. All 14 **continuous variables** initially considered were included as possible predictors in one or more of the seven different logit models. Of these, eight were retained in one or more of the logit models as predictors (p-values $\leq 0,15$) contributing to the different adoption categories. From these eight continuous predictors only one (type of farmer) appears in three different logit models, two predictors (age and livestock income per livestock unit [LSU]) appear in two logit models, and the rest (family size, farming efficiency, herd size, mortality rate and purpose of farming) were significant predictors in only one logit model of adoption.

Of the 20 **categorical variables** initially considered, 13 were included as possible predictors in one or more of the seven different logit models fitted. Of the 13 possible predictors of adoption, 12 were retained in one or more logit models as predictors (p-values $\leq 0,15$) contributing to the different adoption categories. One categorical variable (risk-averse) appears in three different logit models, four variables (financial management, roads, suppliers of inputs/outputs and breeding technology) were significant predictors in two logit models and the rest (technical information [co-farmers], technical information [extension sources], financial information [co-farmers, extension sources], transport, local markets and mating seasons) were only significant predictors for one logit model of adoption.

The high percentage of variables retained in the logit models as predictors for adoption, indicates a good overall selection of possible predictors. As can be seen in the seven different prediction models for adoption of livestock veterinary technologies, there are considerable differences with regard to the significant predictors. This is a clear indication that the separation of livestock veterinary technologies in veterinary surgeon services and in four different types of medication technology (external parasite remedies, internal parasite remedies, antibiotics and vaccines) was necessary and sensibly done.

Table 8.1: **SUMMARY OF LOGIT MODEL RESULTS ON THE ADOPTION OF VETERINARY SURGEON SERVICES AND MEDICATION TECHNOLOGIES**

VARIABLES	Veterinary surgeon services				External parasite remedies		Internal parasite remedies				Antibiotics		Vaccines	
	A vs Po/A & N/A		A & Po/A vs NA		F&O/A vs P/A		F/A vs P/A		O/A vs P/A		P/A vs N/A		P/A vs N/A	
	Para-meter	P>Chi*	Para-meter	P>Chi*	Para-meter	P>Chi*	Para-meter	P>Chi*	Para-meter	P>Chi*	Para-meter	P>Chi*	Para-meter	P>Chi*
CONTINUOUS VARIABLES														
Age					-0,059	0,087	0,088	0,028						
Family size											0,343	0,026		
Farming efficiency			0,036	0,026										
Total livestock income per LSU per year	0,003	0,0002							0,002	0,079				
Herd size													0,011	0,102
Mortality rate in 1997											1,910	0,078		
Purpose of farming									-0,405	0,126				
Type of farmer			0,017	0,073			0,038	0,055					0,024	0,007
CATEGORICAL VARIABLES														
Risk D2 – risk-averse					-1,192	0,143	-2,286	0,051	-2,010	0,071				
Financial management							1,090	0,138	1,309	0,148				
Information – Technical decisions d2 (co-farmers)					2,323	0,142								
Information – Technical decisions d3 (extension sources)					3,529	0,013								
Information – Financial decisions d2 (co-farmers)											-2,097	0,050		
Information – Financial decisions d3 (extension sources)													1,176	0,090
Infrastructure:														
Roads	1,504	0,0038									1,349	0,127		
Transport													-1,687	0,015
Local markets					-0,677	0,024								
Suppliers of inputs/outputs	2,243	0,0004							-2,088	0,067				
Mating seasons					1,611	0,039								
Breeding technology	1,496	0,0101	1,528	0,040										

* p<0,01 = Highly significant p<0,05 = Significant p<0,15 = Relatively significant

A = Adopters; Pot/A = Potential adopters; P/A = Partial adopters; F/A = Full adopters; O/A = Over-adopters; N/A = Non-adopters

The summary of the frequency analysis of the **adoption of medication technology** indicated that none of the 99 farmers were full adopters for all the medication groups simultaneously (external and internal parasite remedies, antibiotics and vaccines). Only 30 per cent of the farmers fully adopted internal and external parasite remedies and partially adopted antibiotics and vaccines. When internal and external parasite remedies are considered, only eight per cent of the farmers fully adopted both technologies, *versus* a 12 per cent partial adoption and nine per cent over-adoption of both medications. On the other hand, only one per cent of the farmers (one farmer) was a non-adopter of internal parasite remedies, antibiotics and vaccines, but was, however, a full adopter of external parasite remedies. This is a further indication that farmers in Qwaqwa are aware of the importance of medication technologies, but that the incorrect usage thereof still poses a problem that needs urgent attention.

If the frequency of adoption of the **veterinary surgeon services** is summarised with the adoption of medication technology, the scenario aggravates to some extent. Of the 99 farmers, only 20 per cent were adopters of veterinary surgeon services as well as full adopters of external parasite remedies and partial adopters of internal parasite remedies, antibiotics and vaccines. Only seven per cent of the farmers were potential adopters of veterinary surgeon services as well as full adopters of external parasite remedies and partial adopters of internal parasite remedies, antibiotics and vaccines.

In Table 8.1 potential adopters of veterinary surgeon services were identified and defined as farmers who would have adopted veterinary surgeon services had it been available and accessible. Thirty-five per cent of the farmers were potential adopters of veterinary surgeon services. Two logit models were fitted; in the first model the potential adopters were grouped with the non-adopters and in the second model the potential adopters were treated as adopters. The results of the two models indicate that the characteristics of the potential adopters gravitate more to those of the adopters than those of the non-adopters.

Some of the continuous variables retained in one or more logistic models as predictors of adoption of livestock veterinary technologies showed interesting results that deserve mentioning. "**Age of farmer**", which appears in two different logistic models, once with a negative coefficient (external parasite remedies) and once with a positive coefficient

(internal parasite remedies), indicates that the younger small ruminant farmers tend to be less conservative and more likely to adopt external parasite remedies, but more conservative towards the use of internal parasite remedies. A possible reason for these contradictory results is that it is relatively more easy to identify (diagnose) external parasite infestations on animals (ticks and scab) and to apply external parasite remedies, than it is to diagnose internal parasite infestation and to apply internal parasite remedies. The correct adoption of internal parasite technologies requires more experience which only comes with time, i.e. age.

Breeding technology used was selected as a significant predictor in the two veterinary surgeon services models. This is an indication that the usage of registered or graded rams contributes to the enhancement of adoption of veterinary surgeon services technologies, and *vice versa*. This result is perhaps obvious because farmers with more expensive breeding stock will take better care of their animals and make more use of veterinary surgeon services. The use of **mating seasons** was a positive predictor for full and over-adoption of external parasite remedies. A high percentage of farmers (79% of full and over-adopters and 46% of partial adopters) were using mating seasons.

Both measurements of **farming efficiency**, **weaning percentage** (technical), and **livestock income per LSU** (financial), emerged as predictors of adoption of one or more livestock veterinary technologies (Table 8.1). Farming efficiency (weaning percentage) emerged as a contributor only to the adoption of veterinary surgeon services (adapted definition, where potential adopters are grouped with adopters). These two efficiency measurement variables (weaning percentage and total livestock income per LSU) can either be predictors for the adoption of veterinary surgeon services or a result of using them. Special care must therefore be taken when analysing and interpreting these variables. In this study these variables are used as predictors. Total livestock income per LSU per year presented positive coefficients in the veterinary surgeon services logit model (conventional definition of adoption) as well as in the internal parasite remedy logit model (over-adopters *versus* partial adopters). This is an indication that a higher livestock income per LSU per year contributes positively to the adoption of veterinary surgeon services and to over-adoption of internal parasite remedies relatively to partial adoption. So it can be generalised that higher financial efficiency contributes to the adoption of veterinary surgeon services and internal parasite remedies and *vice versa*.

Herd size presented interesting results in the sense that it was included as a possible predictor in three of the seven logit models (external, internal parasite remedies and vaccines), but it was only selected as a significant predictor contributing to the adoption of vaccine technology. **Transaction costs** (which in Qwaqwa are mainly transport costs) only play a significant role where farmers have to obtain vaccines. In circumstances where transaction costs form a substantial part of fixed costs, the larger herd sizes contribute to lower the fixed costs per animal unit, which in turn lowers the total costs of adopting new technologies. These results suggest that the fixed cost part of transaction costs on livestock technologies are not so important. This variable was not significant in the other medication models in which the adoption of therapeutic remedies was tested. In a communal grazing system, herd size would not have a major impact on the transmission of diseases and endo- and ecto-parasites as there are frequent contact between different herds. In the case of vaccination, however, the fact that vaccines are sold in large dosages per package and have a short life after being opened, may discourage smaller farmers from adopting vaccines for the treatment of only a few animals, considering that the rest of the vaccine will possibly be wasted.

Sheep, as a percentage of the total small ruminant herd, significantly contributed to the adoption of veterinary surgeon services (adapted definition), full adoption of internal parasite remedies as well as partial adoption of vaccines technology (Table 8.1). This is an indication that sheep farmers are more likely to be adopters of veterinary services and the two mentioned medication groups, than goat farmers, as sheep are more susceptible to internal parasites and diseases than goats.

The variable "**family size**" appeared only in the antibiotics logit model as a significant predictor contributing positively to the partial adoption of antibiotics. This indicates that larger families are more wealthy and thus more likely to adopt antibiotic technologies, probably because they may have more sources of income (spendable money) to buy such expensive medicines for their herds.

Even though the **mortality rates** reported by the local farmers are extremely low (<1,1%), it presented a significantly positive coefficient, which indicates that higher mortality rates will influence or motivate farmers to use antibiotics to lessen the mortality rate among their sick animals.

The negative coefficient of **purpose of farming** on the internal parasite remedies indicates that over-adopters of these remedies regard the keeping of small ruminants for normal commercial farming purposes (selling purposes) as less important than partial adopters. Most of the over-adopters keep animals as an investment or as capital invested that can easily be converted into cash. This manner of "saving" is also related to the need of the farmers to reduce their transaction costs for accessing their capital (withdrawing money). If these farmers have to travel to urban areas every time they need to withdraw money from banks, they would spend a large proportion of the money withdrawn on transport costs. By keeping small ruminants, farmers can easily convert them into cash at local markets, thus reducing the transaction costs involved in the operation.

The negative coefficient of **risk aversion** (Table 8.1), in both the external and internal parasite remedy models, indicates that farmers who are risk-averse are more likely to be only partial adopters, while those who are risk-seeking tend to be full and over-adopters of these two medication groups. This, however, does not mean that risk-averse farmers will not adopt these remedies, but only that they are more cautious when spending money on these medications. Farmers try to protect their profit flow by only applying these remedies when it is absolutely necessary.

The category "**infrastructure**" has three variables which to some extent has a significant influence on the adoption of three of the four groups of livestock veterinary technologies. **Roads** have a positive effect on the adoption of veterinary surgeon services and partial adoption of antibiotics, while **transport** contributes negatively to partial adoption of vaccines and **local markets** contribute negatively to full and over-adoption of internal parasite remedies. These results indicate that farmers with more access to transport and roads favour the adoption of therapeutic technologies to treat already sick animals, while farmers with less access to transport and roads are probably more forced to adopt preventative technology (prophylactic vaccination).

Transport has a negative coefficient in the vaccine logit model (Table 8.1), which indicates that higher availability and accessibility of transport contributes negatively to the adoption of vaccine technologies. This in practice indicates that farmers with access to transport may feel it is unnecessary to use prophylactic treatment on their animals because it would be easy for them to buy antibiotics or to take sick animals to the veterinary surgeon. This hypothesis seems to be confirmed by the fact that roads as infrastructure

contributed positively to the adoption of veterinary surgeon services (conventional definition of adoption) and also to partial adoption of antibiotics. This supports the hypothesis that livestock farmers react on what they see. Inverting this tendency can have far-reaching economic effects on the local small ruminant production system because prophylaxy (prevention) is economically more advantageous than therapy (treatment).

Extension visits did not emerge as a significant contributor to the adoption of livestock veterinary technologies, but technical decisions, using extension sources and co-farmers, indicate that farmers who are full and over-adopters of external parasite remedies and partial adopters of vaccines tend to make their technical and financial decisions by using extension sources and co-farmers as information source. These results further indicate that the present extension service might not be effective when it comes to transferring technical information on the usage of medication technology as farmers are not sufficiently visited by extension officers either on their farms or at the sheering sheds.

The better the availability and accessibility of **input suppliers, output markets and banking services**, the less likely it will be that farmers will be over-adopters relatively to partial adopters. This result implies that if more input suppliers and output markets were available and accessible, and if more advice and information on the use of internal parasite remedies can be provided to farmers, they will tend to use the expensive medication more efficiently and would not become over-adopters. This result is supported by the theory of Von Thünen, who stated that the cost of information becomes too expensive for farmers who are located further away from the sources due to increased transport cost, and that the cost and the quality of information have an influence on the level (correctness) of adoption of new technologies. If the efficiency of the extension services could be improved, and more information could be available to farmers, they will tend to more correctly adopt medication technologies.

8.2 CONCLUSIONS

The following conclusions can be drawn from the results discussed above:

8.2.1 General

- Population growth forced farmers in Old Qwaqwa to move to the mountainous areas, which are further away from the servicing points, resulting in an increase in transportation costs (transaction costs) for inputs and services.

- The absence of extension visits as a predictor of veterinary surgeon services and/or medication adoption may be an indication that extension services are not functional and efficient. Extension visits are a very important determinant of technology transfer and adoption in most of the existing studies, however it does not feature in any of the livestock veterinary technology adoption models in this study.

- Access to credit did not feature as a predictor of livestock veterinary technology adoption, as livestock production systems in Qwaqwa are not capital intensive and when small ruminant farmers are in need of money to buy inputs, they sell some of their stock. In fact, the level of indebtedness amongst the small ruminant farmers is very low.

- Sheep farmers are more likely to use veterinary surgeon services, internal parasite remedies and vaccines, as sheep are more susceptible to diseases and parasites than goats are.

- The variable "location of farmers (Old and New Qwaqwa)" did not emerge as a significant predictor contributing to adoption of any of the livestock technologies, which is against expectations. The data presented complete separation for the variable "Qwaqwa" in the antibiotics and vaccine models where all the non-adopters were from Old Qwaqwa. This result may be an indication that the variables identified by the theory of von Thünen has an influence on the adoption of these two medication technologies as farmers in Old Qwaqwa are situated further away from the input suppliers.

8.2.2 Veterinary surgeon services

- The suspension of veterinary services, provided by the government at the sheering sheds before 1994, contributed to an increase in the costs of these services, inputs and information. Together with the deterioration in infrastructure and institutions, this may

have caused a collapse of the livestock veterinary technology transfer process in Qwaqwa.

- The major constraints of livestock veterinary technologies adoption in Qwaqwa are the flow and cost of information as well as the supply of inputs and services. The withdrawal of the subsidised veterinary and extension services from the servicing points (sheering sheds in Old Qwaqwa and farmer days in New Qwaqwa) have had a negative effect on the correct adoption of livestock veterinary technologies, as well as the profit of the small ruminant farmers as they now have to spend much more money, effort and time to attain services, inputs and information, at centres further away from the sheering sheds.

- The adapted definition for adoption of veterinary surgeon services presented a more accurate model of adoption prediction than the conventional definition, as under inelastic conditions of supply of this technology, the characteristics of potential adopters gravitate more to those of the adopters than to the non-adopters. When the assumption of elastic supply of services or inputs, and increased transportation costs due to the farmer's location is violated, potentially misleading conclusions can be made regarding the significance of variables (predictors) that contribute to the adoption of technologies based on the traditional definition of adoption. If this aspect is ignored by policy-makers, it can lead to inefficient policies on technology transfer and adoption, as it becomes very difficult to clearly interpret the cause/effect relationships between factors.

- Restricted access to roads, the difficult access to the input and output markets, services, information, financial efficiency and the high cost of veterinary services provided by a private veterinary surgeon, are major constraints to most of the potential adopters of the technology "veterinary surgeon services". The availability and usage (adoption) of registered and grade rams, farming efficiency and farming with sheep are in turn contributors to the adoption (conventional definition) of veterinary surgeon services technology.

8.2.3 Medication

- Grouping of medication technology is essential if research on the characteristics of farmers using these technologies have to be estimated. The importance of transport costs, the fact that former homeland farmers react on what they see when it comes to usage of medication technology, makes them more likely to adopt therapeutic (treatment) medication (external, internal remedies and antibiotics) rather than prophylactic (prevention) medication (vaccines), which is evident throughout this study.

- Diffusion programmes in Qwaqwa might have been more effectively done in the past as the veterinary surgeon, the extension and animal health officers have made small ruminant farmers aware of the importance and usage of the most important livestock veterinary technologies (veterinary surgeon services and medication). The absence of a continuous information flow at the sheering sheds (Old Qwaqwa) and farmer days (New Qwaqwa) could have resulted in a high occurrence of incorrect usage of three of the four medication groups (external, internal parasite remedies and vaccines).

- Partial adopters of external parasite remedies are more conservative, older, more risk-averse, do not use extension sources when making technical decisions, have better access to local markets and make less use of mating seasons.

- The usage of internal parasite remedies, which might have been transferred more efficiently before 1994, shows a severe lack of basic knowledge of farmers on the correct application of these drugs as the majority (86%) of the farmers applied these remedies incorrectly.

- The predictor "roads" is perhaps one of the most important predictors of adoption in the antibiotics model. Antibiotics are urgently needed when an animal is already sick. In these cases, farmers must obtain them in a very short time, therefore the availability and accessibility of roads become an important determinant for the adoption of this technology, as medication is no longer available at the sheering sheds.

- Vaccine technology showed the lowest adoption level of the four medication groups studied, which confirms that small ruminant farmers prefer curative intervention above preventative measures.

- When the subsidised veterinary surgeon services, medication and good information were withdrawn from the sheering sheds (Old Qwaqwa) and the farmer days (New Qwaqwa), it is hypothesised that it became too expensive for the farmers to attain the necessary information on the correct use of these drugs because of the longer distances they have to travel to obtain it.

- The high number of variables that emerged as predictors for the adoption in the different models is an indication that the same farmers tend not to be full adopters of all the different livestock veterinary technologies. The fact that only 20 per cent of the farmers were adopters of veterinary surgeon services as well as full adopters of external parasite remedies and partial adopters of internal parasite remedies, antibiotics and vaccines, confirms this conclusion.

8.3 RECOMMENDATIONS

From the conclusions presented above it is clear that something will have to be done to improve the situation of small ruminant farmers. Policies will have to be formulated and further research conducted. This section provides a few suggestions/recommendations in this regard.

8.3.1 Policy

The following aspects may be considered when technology transfer and adoption policies are formulated to accelerate the adoption of livestock veterinary technologies amongst small ruminant farmers in agricultural development programmes:

- Policies to protect the natural resource base of Qwaqwa by controlling the urban expansion of townships, are urgently needed.

- In formulating technology diffusion policies, special attention must be given to ways of increasing farming efficiency as more efficient farmers (technically and financially) tend to adopt more livestock veterinary and medication technologies. The diffusion of new and adapted technologies capable of generating technical and financial incentives is essential. The development of training programmes for farmers to assist them in improving their farm management skills, farming efficiency as well as the correct usage and management of livestock veterinary technologies must also be considered.

- Future technology diffusion programmes on veterinary surgeon services, internal parasite remedies and vaccines must focus more on sheep farmers as their needs are higher than goat farmers. This is a potentially successful target group where diffusion of livestock veterinary technologies should have higher acceptance.

- Special attention must be given to the development of a functional road and transport net-work in Qwaqwa. This is essential to reduce transaction costs of input and output, supply of services and information flow on new technologies.

- Training programmes aiming at the correct usage of medication technologies must be developed and presented to farmers. Competent extension officers, animal health officers and more progressive farmers must be used in this training programmes. Priority must be given by policy-makers to the development and implementation of these programmes.

- Chairpersons of sheering associations can play a very important role in providing better information and logistical assistance to farmers in Qwaqwa in future technology transfer programmes. They must also be acknowledged in future training programmes on development of agriculture. These persons are normally willing to fulfill a very important role in livestock veterinary technology diffusion with little financial assistance. Logistic assistance to supply them with more information, support and training to stimulate farmer-to-farmer diffusion of new technologies is essential to ensure a long-term sustainability of such programmes.

- The improvement of technology transfer and adoption will depend on the re-establishment of a strong and efficient extension service net-work on the former homelands. In order to achieve this, the government may have to consider the following aspects and actions:

  - The reinstitution of a permanent veterinary surgeon and experienced extension and animal health officers provided by the provincial Department of Agriculture at the shearing sheds (Old Qwaqwa) and the farmer days (New Qwaqwa).

  - Continuous training of the existing extension and animal health officers to meet the needs of the farming community and build their human capital capacity.

  - Developing training and extension programmes in accordance with the needs of the farmers in collaboration with the farming community.

  - The implementation of an affordable minimum herd health prophylactic package (basic vaccination and parasite control) with the involvement of the farming community.

  - Looking at ways to develop more self-sustainable extension services. It is a fact and economic reality that extension services for small scale farming in Africa is receiving increasingly less support by governments.

  - Developing the local human capital capacity may be essential to improve adoption of new livestock technologies. Promoting farmer-to-farmer extension may be a way of achieving self-sustainability of extension programmes. One way of doing this, is by means of the development of specific training programmes focussing on the sheering association chairpersons and younger, more progressive and better educated farmers by involving them more in technology diffusion in their farming communities. Sheering association chairpersons are already playing a very active role in the provision of critical technical and financial information for decision-making and usage of new medication technologies.

- Motivating farmers by means of supporting the adoption of affordable minimum herd health prophylactic packages, to control the most frequent diseases and parasites.

- Developing informal education programmes (literacy and arithmetic) as well as basic management training for farmers, to support the adoption and correct usage of medication technologies, as the present level of education is a major constrain to correct adoption.

8.3.2 Further research

Further research on the following aspects is necessary:

- **Characteristics of potential adopters**: It is important to identify the characteristics of potential adopters as well as factors preventing adoption of profitable farming technologies in rural farming and agricultural development areas, as well as in the former homelands of South Africa. This is the ideal target group for future successful diffusion programmes to progressively alleviate poverty in rural areas of the country. Studies in Sudan (Nichola, 1994) and in Nevada (Bhattacharyya *et al.*, 1997) revealed that adoption emerges once the variables preventing adoption are uplifted. It is further important to consider the use of the suggested adapted definition of adoption in future studies on these types of farmers. Additional transport costs increase the price of inputs or services, which cause the supply of inputs or services to become less elastic. Ignoring these facts may lead to policy recommendations that could not solve the real problems.

- **The economical advantages of prophylactic programmes for small ruminants.** Research on the development of a training programme for livestock farmers, which emphasises the economic advantages and incentives of prophylactic medication technology adoption is of great importance. This action may contribute towards productivity, improvement and alleviation of poverty in rural areas.

- **The impact of improved farming efficiency**: Technical and financial efficiency emerged as important contributors towards adoption of livestock veterinary technologies in this study. Research on the development of training programmes on ways to improve farming efficiency may also contribute to the adoption of livestock veterinary technologies and other agricultural technologies, which should increase the wealth of rural farmers with an accompanying improvement of rural economies. The importance of improved efficiency (technical and financial) in the technology transfer and adoption process as determined in this study, need special attention to increase the incentives derived from new technologies.

- **Effect of the level of entrepreneurial and creative skills on technology adoption**: In studies on technology transfer and adoption (Bird, 1989; Cromie & O'Donaghue, 1992; Maasdorp, 1992) it was found that the level of entrepreneurial and creative skills is an important determinant for the adoption of agricultural technologies. Questions asked in this study did not manage to distinguish between entrepreneurs and non-entrepreneurs. Research on the behaviour of former homeland and emerging small ruminant farmers to determine critical factors contributing to the development of entrepreneurial and creative skills, are important to establish sustainable agricultural development programmes in rural areas of South Africa. The development of training programmes in improving the entrepreneurial and creative skills of former homeland and emerging small ruminant farmers can then be developed from the results obtained.

- **Efficiency of traditional livestock medication**: Traditional livestock medication as well as their efficiency, were aspects not attended to in this study because of the low number of farmers using them in combination with modern medication. More research must be done on the efficiency of the locally used herbal and other common remedies.

- **Efficiency of extension services**: Comparative studies on the efficiency of new veterinary and extension services, compared to the old services (before 1994), as well as comparative studies between regions, provinces or even similar communities could be important when advising policy-makers on the approach they can follow in developing rural agriculture in South Africa.

Annexure A

QUESTIONNAIRE

All information provided will be treated as STRICTLY CONFIDENTIAL

TRANSFER AND ADOPTION OF TECHNOLOGY BY SHEEP AND GOAT FARMERS IN QWAQWA : QUESTIONNAIRE FOR PERSONAL INTERVIEW

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Sources: Nichola, T.
Van Schalkwyk, H. D.
Venter, G. C. R. & Madolo, M. C.

General information

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1-4 ☐☐☐☐1

Name of interviewee	
Date of interview	
Respondent's name	
Address: P.O. Box	
Town	
Code	
Telephone number	
Region	
Town/village	

Type of farming (Name one)

Mixed	1
Livestock	2
Crops - Irrigation	3
Crops - Dryland	4
Fruit - Irrigation	5

☐ 5

Kind of farm (tenure status) (Name one)

Private owner	1
Communal	2
South African Development Trust	3
Open access	4
Rent & share cropping	5

☐ 6

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A. Biographical characteristics

A.1 Gender

Male	1
Female	2

☐ 7

A.2 Age in years

	years

☐☐ 8-9

B. Human capital endowments

Education •••••ooo

B.1 What is your highest educational qualifications?

	Farmer	Spouse(s)	Children
None	1	1	1
Grade 5 and lower	2	2	2
Grades 6-7	3	3	3
Grades 8-9	4	4	4
Grades 10	5	5	5
Grades 11-12	6	6	6
Post-matric level	7	7	7

☐ 10
☐ 11
☐ 12

Knowledge - farming experience •••••ooo

B.2 How long have you been farming?	years	☐☐ 13-14
B.3 How long have you been farming on your current farm?	years	☐☐ 15-16
B.4 How long have you been farming with the current enterprises? Crops	years	☐☐ 17-18
Livestock	years	☐☐ 19-20

B.5 Indicate whether you have the following abilities:

	Talk		Read		Write	
	Yes	No	Yes	No	Yes	No
English	1	0	1	0	1	0
Afrikaans	1	0	1	0	1	0
Sotho or any other native language	1	0	1	0	1	0

☐☐☐
☐☐☐
☐☐☐
21-29

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B.6 Indicate your arithmetic abilities

None	1
Little	2
Average	3
Good	4

☐ 30

B.7 Are you or your wife, family of the chief?

Yes	1
No	2

☐ 31

Level of entrepreneurship and creativity •••••ooo

B.8 Rate the farmer (description of the farmer's characteristics) according to the following statements between 4 (strongly agree with the statement) and 1 (strongly disagree with the statement. **(Do not mention the headings to the farmer while completing the questions!!!)**

	Strongly disagree	Disagree	Agree	Strongly agree	
8.1 Leadership					
You are not afraid to try a new technique (pesticide) before your fellow farmers and you will try to do it on your own before seeking help. (Self-starter) Na ha o tsabe ho ka qala mokgwa o mong o motjha wa ho laola/ho thibela dikokonyana-hloko (mekgasa) pele ho dihwai tse ding pele o ka kopa thuso?	1	2	3	4	☐ 32
If you decide to do something on your farm, you will do it and nothing will stop you from doing it. Haeba o ikemiseditse ho etsa ntho e itseng polasing/ mohlapeng wa hao, ha ho na le se ka o thibelang ho etsa seo/jwalo?	1	2	3	4	☐ 33
Even though people tell you "it can't be done", you have to find it out for yourself. Haeba maikemisetsang av a hao batho ba o eletsa hire o keke wa tswella o tla qetella o entse jwang?	1	2	3	4	☐ 34
8.2 Need for achievement of goals					
If you have a problem (challenge) on your farm you will keep on trying to solve the problem (challenge) and you will not quit. Haeba o na le bothata polasing/mohlapeng na o tla leka ho lokisa bothata boo kapa o tla bo tlohela ho fihlela bo o hlola na? Mohlala phokojwe e bolaya makonyana ka ho tlolela ka sakeng la hao bosiu?	1	2	3	4	☐ 35
You have the ability to organise the four production factors (land, labour, capital and management) in such a way that the goals set for the farm are achieved. Na ha o ka fuwa masimo/tjhelete/peo ho ntshetsa pele mohlap, o ka kgona ho sebedisa kapa o ka e sebedisa bakeng se seng/morerong o mong o sele?	1	2	3	4	☐ 36

	Strongly disagree	Disagree	Agree	Strongly agree	For office use only
8.3 Creative skills					
You have the ability to adapt to changes in the farming environment. If the price of beef declines and the price of mutton (sheep) increases are you able to change your farming practices in such a way that you can start producing mutton for the higher demand? Na ha theko ya nama ya kgomo e ewa, mme nama ya nku e phahama na o ka leka ho hlahisa nama ya nku e ngata na? Na o ka ikamahanya le diphetoho na? Ho latela maemo?	1	2	3	4	☐ 37
You are always looking for opportunities to increase the profit of your farm (The creation and identifying of new markets for products. Have the ability to start growing a new crop, in some cases add value and create a new market for the new product.) Na o leka ka matla ho eketsa phaello ya hao ka ho batla nmaraka moo o ka rekisang tlhahiso (boya/ lebese jj) teng ho fuma ha tjhelete ya hao?	1	2	3	4	☐ 38
8.4 Motivation to progress					
You are not dependent on subsidies or other incentives to adopt new technologies. Na hore o etse diphetoho tse isang katlehong o itshetlehile ditlhaisong tse tswang mmusong kapa o ka di etsa ka bowena na?	1	2	3	4	☐ 39
You like supporting and helping your fellow farmers when you see they are struggling or when they come to you with problems. Na o ka thabela ho thusa dihwai tse ding ha di na le mathata. Kopa o ka thabele ha ba hloleha ho atleha (mohlala mohlape wa bona o kula,/ o utsuwa).	1	2	3	4	☐ 40
8.5 Need for autonomy					
You do not often need to ask other people's opinions before you decide on important things - you can rely on your own knowlege or family to make good decisions. Na ha o ikemiseditse ho etsa ntho e itseng. O ka thabela ho utlwa maikutlo a ba tho ba bang ka sepheo sa hao na?	1	2	3	4	☐ 41
You are not afraid to be different when it comes to the adoption of new technologies on your farm. Na ha o tshabe hoba mokgelo tlhahisong kapa nltafatsong?	1	2	3	4	☐ 42
8.6 Attitude towards risk (See D7)					

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Planning skills •••••ooo

B.11 To what extent do you plan (maikemisetso) for the future?

Thorough plans and objectives stated	4
Some plans (rough, incomplete)	3
Only some idea about planning	2
No plans (not considered)	1

☐ 43

B.12 How long in advance do you think is it necessary to plan (maikemisetso)?

	days

☐☐☐☐ 44-47

B.13 What are the future plans for the farm?

Indicate in sequence of importance what future plans you have	Specify in terms of herds of cattle or hectare	How do you plan to achieve these objectives?
1.		
2.		
3.		
4.		

☐☐ 48-49
☐☐ 50-51
☐☐ 52-53

☐☐ 54-55
☐☐ 56-57
☐☐ 58-59

☐☐ 60-61
☐☐ 62-63
☐☐ 64-65

☐☐ 66-67
☐☐ 68-69
☐☐ 70-71

B.14 What do you think is the most important financial strategies you must follow (planning that you must do in future) to make a long term success of your farm? Place it in sequence of importance from 1 to 5.

	Not important		Important		Very important
To have sole land rights	1	2	3	4	5
Keep production costs low	1	2	3	4	5
Must get financial management training before I start farming	1	2	3	4	5
My farm must earn a substantial profit for growth	1	2	3	4	5
I must be able to honour my instalments each year	1	2	3	4	5

☐ 72
☐ 73
☐ 74
☐ 75
☐ 76

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1-4 | | | | 2

Decision-making •••••ooo

B.15 Who makes the following agricultural decisions? (Mark only the most important one in each column)

	Technical	Financial
Husband	1	1
Wife	2	2
Husband and wife	3	3
Husband, wife and children	4	4
Father	5	5
Husband and father	6	6
Mother	7	7
Manager	8	8
Husband and manager	9	9
Other (specify)	10	10

5-6
7-8

Financial management •••••ooo

B.16 Do you keep any farming records?

Yes	1
No	2

9

If "yes", which records?	Thorough neat	Rough incomplete	Only idea	None	
Cost records	4	3	2	1	10
Income records	4	3	2	1	11
Production records: Crops	4	3	2	1	12
Production records: Livestock	4	3	2	1	13
Labour records	4	3	2	1	14
Inventory records	4	3	2	1	15
Other (Specify): 1.	4	3	2	1	16
2.	4	3	2	1	17
3.	4	3	2	1	18
4.	4	3	2	1	19

B.17 Do you think that keeping records is important?

Yes	1
No	2

20

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B.18 If "yes", how important is the records to you?

	Not important	Important	Very important	
Determining financial position	1	2	3	☐ 21
Decision-making and planning	1	2	3	☐ 22
To keep the bank or co-op manager happy	1	2	3	☐ 23
Other (Specify)	1	2	3	☐ 24
				☐ 25
				☐ 26

1-4 ☐☐☐☐ 3

Marketing management ••••ooo

B.19 Are there output markets available within an accessible distance from your farm?

Yes	1
No	2

☐ 5

B.20 Through which marketing system do you market your livestock?

	Livestock type			
	Sheep	Goats	Wool & Skins	Hair & Skins
Auction or public sale	1	2	3	4
%				
Open market in town	1	2	3	4
%				
Private sale	1	2	3	4
%				
Local trader or cooperative	1	2	3	4
%				
Own consumption	1	2	3	4
%				
Value adding direct marketing	1	2	3	4
%				
Other (Specify)	1	2	3	4
%				

☐☐☐☐☐☐ 6-17
☐☐☐☐☐☐ 18-29
☐☐☐☐☐☐ 30-41
☐☐☐☐☐☐ 42-53
☐☐☐☐☐☐ 54-65
☐☐☐☐☐☐ 66-77
☐☐☐☐☐☐ 78-89

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Resources

Farm size and land-use •••••ooo

1-4 [ ][ ][ ][4]

C.1 Land-use

	Private ownership (ha)	Share cropping (ha)	Rented land (ha)	State land for which no rent is paid (ha)	Communal land (ha)	Partnership (ha)	Total area (ha)	
Croplands								
Irrigation								5-7
Dryland								8-10
Pastures								
Irrigation								11-13
Dryland								14-16
Orchards & vineyards								17-19
Veld								20-22
Total area (ha)							R	23-25

Farm size and land use and gross farm income •••••ooo

C.2 Please provide the following information regarding last season's crops as well as what is planned for the coming season.

		1 Maize	2	3	4	5	6	Total	
Dryland:									
Area planted	1996								
	1997								
Total yield (ton/kg)	1996								
	1997								
Total income (R)	1996							R	26-31
	1997							R	32-37

		1 Maize	2	3	4	5	6	Total	
Irrigation:									
Area planted	1996								
	1997								
Total yield	1996								
	1997								
Total income (R)	1996							R	38-43
	1997							R	44-49

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Other farm income ·····ooo

C.3 Do you render services to other farmers?

Yes	1
No	2

☐ 50

C.4 If "yes", are you paid for the services rendered?

Yes	1
No	2

☐ 51

C.5 If 'yes", please state the source and amount received.

Source	Rand
Total per year	R

52-56 ☐☐☐☐☐

Non-farm income ·····ooo

C.6 Apart from income derived from farming, does any one of the household have any other form of income which is also used for farming purposes?

Yes	1
No	2

☐ 57

C.7 If "yes", please use the following scale to complete the table:

Scale	Code
R0 - R500	1
R5 001 - R10 000	2
R10 001 - R15 000	3
R15 000 - R20 000	4
R20 001 - R25 000	5
R25 000>	6

Member of household	Source of income (e.g. café, taxi, pension, rental income from house, land or natural veld, etc.)	Code	Amount (R)
1.			
2.			
3.			
4.			
Total income			R

58-63 ☐☐☐☐☐☐

C.8 If "yes" at C.6, with what did you start?

Farm	1
Business	2
Job	3

☐ 64

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1-4 ☐☐☐☐ 4

Labour •••••ooo

C.9 Family size at time of interview

Adults	Number	
Elders 55 years and older		5-6
Middle-aged 35-54 years		7-8
Young adults 15-34 years		9-10
Children (own) and relatives who stay permanently in your home		
Older children (7-14 years)		11-12
Younger children (6 and under)		13-14
Total family size		15-16

C.10 How many of your children and relatives work on your farm? ☐ No. of people 17-18

C.11 Do you employ permanent labour? Yes 1 / No 2 ☐ 19

C.12 If "yes", how many? ☐ Labourers 20-21

C.13 Do you employ seasonal or casual labour? Yes 1 / No 2 ☐ 22

C.14 If "yes", how many per year? ☐ Labourers 23-24

C15. If "yes", how many days per year? ☐ Days 25-26

Capital - Credit •••••ooo

C.16 Do you make use of any foreign capital? Yes 1 / No 2 ☐ 27

C.17 If "yes", name the source, type, interest rate and amount outstanding on 1/1/98.

Source (Commercial Bank/Co-op)	Type (Hire purchase/bond/ overdraft/production loan	Interest rate (%)	Amount (R)	
Formal sources				
Commercial Bank				28-37
Agricultural cooperative				38-47

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Agricultural Bank of South Africa			
Agri-mark			
Informal sources			
Credit unions			
Credit clubs			
Family and friends			
Stokvels			

48-57 | 58-67 | 68-77 | 78-87 | 88-97 | 98-107 | 1-4 6

C.18 Do you need credit?

Yes	1
No	2

5

C.19 Is credit available?

Yes	1
No	2

6

C.20 If "no", please state why not.

Do not need extra money - have enough money of your own to buy inputs	1	7
Have no access to credit	2	8
The cost (interest) of money is too high	3	9
Bank does not want to lend me money due to insufficient security	4	10
Poor repayment ability of farm	5	11
Other (Specify):	6	12 13
	7	14 15

C.21 How do you buy the inputs for the sheep and/or goats? (feed licks, male breeding stock [sires], medicine, etc.) (Mark only one)

Use only own funds	1	
Buy only on credit	2	
Combination of own funds and credit	3	16

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D. Risk management

Risk (Ho nka mathata) •••••ooo

D.1 Do you use remedies for parasites, diseases and/or sickness for sheep and/or goat?

Yes	1
No	2

☐ 17

If "no", complete D.2 and D.3 and go to question D.6. If "yes", go to question D.4.

D.2 Do you think that the use of sheep and/or goat remedies for parasites, diseases and/or sickness will increase your risk?

Yes	1
No	2

☐ 18

D.3 If "yes" at question D.2, why do you say so?

Specify, i.e. if there is a drought I will not be able to repay my debt	1	☐ 19
	2	☐ 20
	3	☐ 21
	4	☐ 22
	5	☐ 23
	6	☐ 24

D.4 If "yes" at D.1, did the adoption of sheep and/or goat remedies for parasites, diseases and/or sickness change your attitude towards risk?

Yes	1
No	2

☐ 25

D.5 If "yes" at D.4, in which way?

	1	☐ 26
	2	☐ 27
	3	☐ 28
	4	☐ 29
	5	☐ 30
	6	☐ 31
	7	☐ 32

D.6 If more definite information were available on the results of higher reproduction with the usage of sheep and/or goat remedies for parasites, diseases and/or sickness, would it have an influence on your attitude towards the risk involved in the usage of these remedies?

Yes	1
No	2

☐ 33

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D.7 **Attitude towards risk**: Which <u>one</u> of the following situations will you choose in your farming operation?

Variety A will give you a profit of R10 000 in two out of ten years and in the other eight years R0 (High profit, high risk) Sehlahiswa sa A se tla ofa phaello ya R10 000 lemong tse pedi tsa tse leshome (phaello e hodi-mo monyet la wa ho lahlehalwa o moholo)	1
Variety B will give you a profit of R3 000 in six out of ten years and in the other four years R0 (Medium profit, medium risk) Sehlahiswa sa B se tla ofa phaello ya R3 000 lemong tse tsheletseng tsa tse leshome (phaello e mahareng le monyetla wa tahlehelo o mahareng)	2
Variety C will give you a profit of R2 000 in eight out of ten years and in the other two years R0 (Low profit, low risk) Sehlahiswa sa C se tla ofa phaello ya R2 000 lemong tse robedi tsa tse leshome (phaello etlase le monyet la wa tahlehelo o tlase)	3

☐ 34

E. Livestock technologies

E.1 Complete the following information.

Numbers	Cattle	Mutton sheep	Wool sheep	Boer goats	Angora goats	Pigs	Poultry	Other
Male stock								
Female								
Offspring								
Total								
Number weaned per year								
Weaning percentage (%)								
Numbers sold per year								

35-48

Income per year (1996)	Cattle	Mutton sheep	Wool sheep	Boer goats	Angora goats	Pigs	Poultry	Other
Meat sales								
Milk, wool, skins & hair								
Own consumption (meat)								
Own consumption (milk)								
Dung (manure) sold								
Total income								

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Losses per year	Cattle	Mutton sheep	Wool sheep	Boer goats	Angora goats	Pigs	Poultry	Other
Dead (older than one year)								
Dead (younger than one year)								
Total								
Stolen (older than one year)								
Stolen (younger than one year)								
Total								

49-64

65-80

Income per year (1997)	Cattle	Mutton sheep	Wool sheep	Boer goats	Angora goats	Pigs	Poultry	Other
Meat sales								
Milk, wool, skins & hair								
Own consumption (meat)								
Own consumption (milk)								
Dung (manure) sold								
Total income								

1-4

7

Losses per year	Cattle	Mutton sheep	Wool sheep	Boer goats	Angora goats	Pigs	Poultry	Other
Dead (older than one year)								
Dead (younger than one year)								
Total								
Stolen (older than one year)								
Stolen (younger than one year)								
Total								

5-20

21-36

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E.2 Indicate what type of male breeding stock you use (Mark only one per livestock type. If more than one source is used, mark the major source.)

	Mutton sheep	Wool sheep	Boer goats	Angora goats	
Borrow the neighbour's male stock					37-40
Any male stock the farmer can get hold of					41-44
Locally bred male (grade) stock					45-48
Registered bred male stock					49-52
Artificial insemination					53-56
Communal owned male stock					57-60
Own bred					61-64
Other (specify)					65-68

E.3 If you do not use registered or grade male stock (sires) give the reason why. (Mark as many as are applicable)

1-4 | 8

Male breeding stock are too expensive	1	5-6
Have no money (cash) available to buy male breeding stock	2	7-8
Cannot get credit to buy male breeding stock	3	910
Male breeding stock is not easily accessible	4	11-12
Have no transport to get the male breeding stock to my farm	5	13-14
The transport is too expensive to get the male breeding stock to my farm	6	15-16
Male breeding stock will not have a large enough effect on my reproduction levels to pay for the extra expenses	7	17-18
It will increase the production risk of my farm	8	19-20
It will increase the financial risk of my farm due to higher debt	9	21-22
Decent male breeding stock is not freely available	10	23-24
Other (specify)	11	25-26
	12	27-28
	13	29-30

E.4 Do you make use of mating seasons?

Yes	1	
No	2	31

E.5 If "yes", indicate the mating season (Mark where applicable)

	Mutton sheep	Wool sheep	Boer goats	Angora goats	
Summer					32-35
Autumn					36-39
Winter					40-43
Spring					44-47

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E.6 Indicate the importance for keeping different types of livestock by allocating a mark from 1 to 4 with 1 as unimportant and 4 as very important.

	Mutton sheep	Wool sheep	Boer goats	Angora goats	
Cultural and religious purposes					48-51
Own consumption (milk & meat)					52-55
To reduce risk (diversification)					56-59
As an investment					60-63
Normal farming					64-67
Source of money in case of emergency					68-71
Other (specify)					72-75
					76-79
					80-83

1-4 | 9

E.7 Do you make use of veterinary surgeon services for sheep and goats?

Yes	1
No	2

5

E.8 If "yes":

Only when sheep or goats become sick	1
On a frequent basis	5

6

E.9 If veterinary surgeon services are used on a frequent basis, indicate how many times per year.

Once per year	1
Twice per year	2
Three times per year	3
Four times per year	4
Five times per year	5
Six times per year	6

7

E.10 If you **do not** make use of veterinary surgeon services, please indicate as many reasons as applicable, why not.

Veterinary surgeon services are too expensive	1	8-9
Have no money (cash) available to afford veterinary surgeon services	2	10-11
Cannot get credit to make use of veterinary surgeon services	3	12-13
The veterinary surgeon services are not easily accessible	4	14-15
Have no transport to get the sick livestock to veterinary surgeon services	5	16-17
The veterinary surgeon services will not have a large enough effect on my reproduction levels to pay for the extra expenses	6	18-19

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It will increase the production risk of my farm	7	20-21
It will increase the financial risk of my farm due to higher debt	8	22-23
Am involved in organic farming	9	24-25
Cultural reasons	10	26-27
Other (specify)	11	28-29
	12	30-31
	13	32-33

E.11 Do you make use of external parasite (ticks), internal parasite, disease control vaccines or general mediction?

Yes	1	
No	2	34

E.12 If "yes", indicate the name of the remedy as well as the number of times per year in the applicable square.

Type of medication	Name of remedy	Type of animal			
		Mutton sheep	Wool sheep	Boer goats	Angora goats
External parasite control (Ticks) (e.g. Deadline)					
1.					
2.					
3.					
4.					
Internal parasite control (e.g. Ranide, Valbasen)					
1.					
2.					
3.					
4.					
Disease vaccination control (e.g. Pulpy Kidney, Brucelosis. etc.)					
1.					
2.					
3.					
4.					
General medication (e.g. Terramycin, Eye powder, etc.)					
1.					
2.					
3.					
4.					
Traditional remedies (e.g. Natural plants)					
1.					
2.					
3.					
4.					

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E.13 If you **do not** use EXTERNAL PARASITE REMEDIES (for ticks) please indicate as many reasons as applicable, why not.

The remedies are too expensive	1	35-36
Have no money (cash) available to buy the remedies	2	37-38
Cannot get credit to buy the remedies	3	39-40
The remedies are not easily accessible	4	41-42
Have no transport to get the remedies to my farm	5	43-44
The remedies will not have a large enough effect on my reproduction levels to pay for the extra expenses	6	45-46
It will increase the production risk of my farm	7	47-48
It will increase the financial risk of my farm due to higher debt	8	49-50
Am involved in organic farming	9	51-52
Cultural reasons	10	53-54
Difficult to use and handle	11	55-56
The remedies are not freely available	12	57-58
Do not know how to use remedy	13	59-60
Do not know there is a remedy	14	61-62
Other (specify):	15	63-64

E.14 If you **do not** use INTERNAL PARASITE REMEDIES, please indicate as many reasons as applicable, why not.

The remedies are too expensive	1	65-66
Have no money (cash) available to buy the remedies	2	67-68
Cannot get credit to buy the remedies	3	69-70
The remedies are not easily accessible	4	71-72
Have no transport to get the remedies to my farm	5	73-74
The remedies will not have a large enough effect on my reproduction levels to pay for the extra expenses	6	75-76
It will increase the production risk of my farm	7	77-78
It will increase the financial risk of my farm due to higher debt	8	79-80
Am involved in organic farming	9	81-82
Cultural reasons	10	83-84
Difficult to use and handle	11	85-86
The remedies are not freely available	12	87-88
Do not know how to use remedy	13	89-90
Do not know there is a remedy	14	91-92
Other (specify):	15	93-94

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1-5 | | | | 1 | 0 |

E.15 If you **do not** use DISEASE VACCINES, please indicate as many reasons as applicable, why not.

The remedies are too expensive	1	6-7
Have no money (cash) available to buy the remedies	2	8-9
Cannot get credit to buy the remedies	3	10-11
The remedies are not easily accessible	4	12-13
Have no transport to get the remedies to my farm	5	14-15
The remedies will not have a large enough effect on my reproduction levels to pay for the extra expenses	6	16-17
It will increase the production risk of my farm	7	18-19
It will increase the financial risk of my farm due to higher debt	8	20-21
Am involved in organic farming	9	22-23
Cultural reasons	10	24-25
Difficult to use and handle	11	26-27
The remedies are not freely available	12	28-29
Do not know how to use remedy	13	30-31
Do not know there is a remedy	14	32-33
Other (specify):	15	34-35

E.16 If you **do not** use GENERAL MEDICATION REMEDIES, please indicate as many reasons as applicable, why not.

The remedies are too expensive	1	36-37
Have no money (cash) available to buy the remedies	2	38-39
Cannot get credit to buy the remedies	3	40-41
The remedies are not easily accessible	4	42-43
Have no transport to get the remedies to my farm	5	44-45
The remedies will not have a large enough effect on my reproduction levels to pay for the extra expenses	6	46-47
It will increase the production risk of my farm	7	48-48
It will increase the financial risk of my farm due to higher debt	8	50-51
Am involved in organic farming	9	52-53
Cultural reasons	10	54-55
Difficult to use and handle	11	56-57
The remedies are not freely available	12	58-59
Do not know how to use remedy	13	60-61
Do not know there is a remedy	14	62-63
Other (specify):	15	64-65

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F. Information and training sources

If an extension officer accompanies you, he must leave you and the farmer alone at this stage. (Arrange with the extension officer before the visit to leave you and the farmer while you are busy with the livestock information.)

1-5 [ ][ ][ ][1][1]

Training - Informal (short courses in agriculture) •••••ooo

F.1 Did you receive any training on the technologies you adopted on your farm?

Yes	1
No	2

[ ] 6

Information •••••ooo

F.2 What source(s) of information do you use or approach when you have to make the following decisions, acquire information or need training? (Mark as many as are applicable)

	Technical decisions	Financial decisions	Marketing decisions	Information on new tech-nologies	Training	
Radio						7-11
Television						12-16
Extension publications (all leaflets, periodicals)						17-21
Co-farmers - neighbours						22-26
Department of Agriculture - Extension officers						27-31
Cooperative - Extension officers						32-36
No one - use own physical or technical records						37-41
No one - use own financial records						42-46
Bank manager						47-51
Supplier of inputs like the cooperative manager						52-56
Sell to the buyer who is the closest to my farm - do not consider different markets						57-61
Market agents						62-66
Read in the press (newspapers, magazines, etc.)						67-71
Veterinary surgeon						72-76
Chief						72-81

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Chair person sheering association					
Other (specify):					

82-86
87-91
92-96
97-101
102-106
107-111

1-5
1 2

F.3 Do you need any extension advice?

Yes	1
No	2

6

F.4 If "yes", is one of the following extension officers available when you need them?

	Yes	No	
Government extension officers	1	0	7
Cooperative extension officers	1	0	8
Input suppliers extension officer companies (seed, fertiliser, chemicals, feed, animal medicine, etc.)	1	0	9

F.5 How many times have you been visited by an extension officer this past season?

Government extension officers		Times	10-11
Cooperative extension officers		Times	12-13
Input suppliers extension officers		Times	14-15
TOTAL		Times	16-17

F.6 Do you think the extension officer has enough knowledge to supply you with the necessary information you need on your technical and financial management needs?

	Technical		Financial		
	Yes	No	Yes	No	
Government extension officers	1	0	1	0	18-19
Cooperative extension officers	1	0	1	0	20-21
Input suppliers extension officer companies (seed, fertiliser, chemicals, feed, animal medicine, etc.)	1	0	1	0	22-23

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G. Institutions

G.1 Indicate which of the following institutions' services are freely and easily accessible to you, the farmer.

Government extension system	1	☐ 24
Cooperative extension system	2	☐ 25
Agricultural research	3	☐ 26
Input suppliers (businesses where farmer can buy seed, fertiliser, fuel, etc.)	4	☐ 27
Output markets (institutions like the co-op where you can market your outputs)	5	☐ 28
Banking services	6	☐ 29
Other (specify)	7	☐ 30 ☐ 31 ☐ 32

H. Infrastructure

H.1 Indicate which of the following infrastructures are freely and easily accessible or available to you, the farmer.

Roads	1	☐ 33
Transport	2	☐ 34
Telephone	3	☐ 35
Electricity	4	☐ 36
Local markets	5	☐ 37
National markets	6	☐ 38
International markets	7	☐ 39
Other (specify)	8	☐ 40 ☐ 41

Annexure B

MODELS USED IN THIS STUDY

B.1 The logit model

B.2 The multinomial logit model

B.3 The probit model

B.4 Dummy variables

B.1 THE LOGIT MODEL

The theory of technology adoption shows a traditional sigmoid (S) curve trend in the sense that the technology adoption process has at first a slow increasing trend with time, and as soon as the adopter starts to use or implement new technologies and the utility or incentives obtained are sufficiently realised by the farmer, the adoption process accelerates. After the implementation of a set of new technologies, the acceleration process declines until new technologies appear again.

The standard cumulative **logistic distribution function** is given by:

$$P_i = E(Y = 1|X_1) = \frac{1}{1 + e^{-(a_0 + \beta_2 X_i)}} \qquad \text{(B.1)}$$

where P is the probability that a farmer will "adopt" or "not adopt" new technologies, given the values in the vector of the explanatory variables **X** (x_1, x_2, x_3, ...x_n). The β is a vector of the coefficients (b_1, b_2, b_3, ...b_n), and e represents the base of the natural logarithm.

OR:

$$P_i = \frac{1}{1 + e^{-(a_0 + B_2 X_i)}} \qquad \text{(B.2)}$$

The $(\alpha_0 + \beta_2 X_2)$ function ranges from $-\infty$ to $+\infty$, P_i ranges between 0 and 1 and P_i is non-linearly related to $\alpha_0 + \beta_2 X_2$ (i.e., X_i). Note that P_i is nonlinear not only in X but also in the β's as can clearly be seen from (B.2). This means that the **ordinary least square** (OLS) procedure cannot be used to estimate the parameters (Gujarati, 1988). The

maximum likelihood (ML) estimation can be applied to eliminate this problem, as it generates consistent coefficient estimates (Park & Kerr, 1990:103).

If P_i, the probability of adopting technology, is given by (B.2), then (1 – P_i) is the probability of not adopting new technologies and can be written as

$$1 - P_i = \frac{1}{1 + e^{(\alpha_0 + \beta_2 X_i)}} \tag{B.3}$$

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{(\alpha_0 + \beta_2 X_i)}}{1 + e^{-(\alpha_0 + \beta_2 X_i)}} = e^{(\alpha_0 + \beta_2 X_i)} \tag{B.4}$$

$P_i / (1 - P_i)$ is simply the **odds ratio** in favour of adopting new technologies.

If the natural log of (B.4) is taken, the result is the following function:

$$L_i = \ln\left(\frac{P}{(1 - P_i)}\right) = \alpha_0 + \beta_{2i} \tag{B.5}$$

where L_i is the log of the odds ratio of the dependent variable (Gujarati, 1988).

The logit model will be used with the analysis of veterinary surgeon services adoption, external parasite remedies and vaccine adoption. When the model to be estimated has more than two categories or dummy dependent variables, the multinomial logit model, which is an extension of the logit model, must be used.

B.2 THE MULTINOMIAL LOGIT MODEL

Many cases in the research world exist where there are more than two qualitative choices available to be analysed. If multiple alternatives can occur simultaneously, a better approach to use, according to Park and Kerr (1990), is a **multinomial logit model**. This is an extension of the binomial logit technique. If there are n different alternatives, $n - 1$ dummy variables are needed to describe the specific adopter, with each dummy equalling one only when that particular adoption alternative occurs. In the multinomial logit model one alternative is selected as the "base"alternative and then each other possible choice is compared to this base alternative with a logit equation. The literature does not refer to a specific alternative to be chosen as the base alternative; any one can be used. A key distinction is that the dependent variable of these equations is the log of the odds of the i^{th} alternative being chosen compared to the base alternative (Park & Kerr, 1990; Studenmund, 1997):

$$\ln = \left(\frac{P_{1i}}{P_{bi}} \right) \tag{B.6}$$

Where:

P_{1i} = the probability of the i^{th} person choosing the first alternative; and

P_{bi} = the probability of the i^{th} person choosing the base alternative.

If one takes the adoption example (n = 3) and it is decided that full adopters are the "base" alternative, then a multinomial logit model will have a system of two equations:

$$\ln(P_{P/Ai} / P_{F/Ai}) = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \varepsilon_{P/Ai} \tag{B.7}$$

$$\ln(P_{N/Ai} / _{F/Ai}) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \varepsilon_{P/Ai} \tag{B.8}$$

where P/A = partial adopters, N/A = non-adopters, and F/A = full adopters,

Definitions of the independent (explanatory) variables are unusual in a multinomial logit function. Some of the characteristics of the X's are of the decision-maker (farmer). The coefficients of these variables represent the ratio between the impact (of the *utility or incentive*) of the new technology on the probability of choosing one mode (to partially adopt new technologies) and the impact (of the *utility or incentive*) of the new technology on the probability of choosing the base mode. For example, in Equation B.7, if X_1 is herd size, the coefficient α_1 is the impact of an extra livestock unit (LSU) on the probability of partial adoption of medication technologies *minus* the impact of an extra LSU on the probability of full adoption of new medication technologies (holding X_2 constant).

The multinomial logit model has all the basic properties of the logit model but with two additional complications in its estimation. First, Equations B.8 and B.9 are estimated simultaneously, so the iterative nonlinear maximum likelihood procedure used to estimate the system is more costly than for the logit model. Secondly, the relationship between the error terms in the equations (ε_{pi} and ε_{ni}) must be strictly accounted for by using a generalised least squares (GLS) procedure (Ramanathan 1992), a factor that also complicates the estimation procedure (Park & Kerr, 1990; Studenmund, 1997).

The multinomial logit model will be used with the analysis of external parasite remedies and antibiotic technologies.

B.3 THE PROBIT MODEL

This model is, according to Gujarati (1988), also used in modelling where equations with dummy dependent variables (Y=1 for adopters and Y=0 for non-adopters) are used. The **logit** and the **probit** models are quite comparable, therefore the choice between the two is of mathematical convenience and ready availability of computer programmes. Where the **logit** model is based on a **logistic** cumulative distribution function (CDF), the **probit** is based on a **normal** CDF. The probit model is mainly used where the utility theory, or rational choice perspective on behaviour is used. In the example of technology adoption, the decision of the i^{th} farmer adopting new technologies or not, will depend on an

unobservable utility index I_i that is determined by an explanatory variable(s), X_i , in such a way that the larger the value of the index I_i, the greater is the probability of the farmer adopting new technologies. The index I_i can be presented as follow:

$$I_i = \beta_1 + \beta_2 X_i \tag{B.9}$$

where X_i is one of the explanatory variables that have an influence on the decision of the i^{th} farmer adopting new technologies (Gujarati, 1988).

Each farmer will have a threshold level for the index, I^*_i such that if I_i exceeds I^*_i the farmer will adopt new technologies. Given the assumption of normality, the probability that I^*_i is less than or equal to I_i can be computed from the standardised normal CDF as:

$$P_i = \Pr(y = 1) = \Pr L(I^*_i \leq I_i) = F(I_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Ti} e^{-\frac{t^2}{2}} dt \tag{B.10}$$

$$= \frac{1}{\sqrt{2\pi}} - \int_{-\infty}^{\beta_1 + B_2 X_1} e^{-\frac{t^2}{2}} dt \tag{B.11}$$

where t is a standardised normal variable, i.e. $t \sim N(0,1)$.

B.4 DUMMY VARIABLES

B.4.1 Categorical dummy explanatory variables with two categories

The simplest case of binary or dummy variables is where a single categorical variable has two categories that affect only the intercept term α. Dummy variables are numeric and are used in econometric formulation. A dummy variable D can be defined as follows:

D = 1 the farmer have a financial record system

D = 0 the farmer does not have a financial record system (B.12)

The intercept α is different for the two categories which is specified as $\alpha = \alpha_0 + \alpha_1 D$. If the farmer has no financial record system D = 0 and $\alpha = \alpha_0$. If the farmer has a financial record system D = 1 and $\alpha = \alpha_0 + \alpha_1$. The difference in the intercept due to whether a farmer has a financial record system or not, is measured by α_1. Substituting for α, the logit function (equation B.2) can be written as follows (Ramanathan, 1992):

$$P_1 = \frac{1}{1 + e^{-a_0 + a_1 D + b_2 X_i}} \quad \text{(B.13)}$$

α_0, α_1 and β_2 are estimated by regressing P_i against a constant, against D, and against X. The estimated relationships for the two categories are:

Financial record system: $-1 + e^{-((\alpha_0 + \alpha_1) + \beta_2 X_1)}$ (B.14)

No financial record system: $-1 + e^{-(\alpha_0 + \beta_2 X_1)}$ (B.15)

B.4.2 Categorical dummy explanatory variables with more than two categories

The number of the possible categories in a categorical dummy explanatory variable might be more than two. For example, let P_f be the farmer who have adopted new technologies in full and it is hypothesised that there is a relationship between full adoption and his risk attitude. How should the farmer's risk attitude be accounted for [risk-aversive (RA), risk-neutral (RN), and risk-seeking (RS)]? The procedure here is to choose one of the categories as a control (base) category and define dummy variables for the other two categories. More specifically, defined:

$A_1 = 1 -$ RA

$A_1 = 0 -$ RS (otherwise) (B.16)

$A_2 = 1 -$ RN

$A_2 = 0 -$ RS (otherwise) (B.17)

The control (base) group (that is, the one for which both A_1 and A_2 are zero) is all the farmers who are risk-seeking. To allow for α to be different for the different categories, it is assumed that $\alpha = \alpha_0 + \alpha_1 A_1 + \alpha_2 A_2$. Substituting this into equation B.2 the function is as follows:

$$P_i = \frac{1}{1 + e^{-(\alpha_0 + \alpha_1 A_1 + \alpha_2 A_2 + \beta_2 X_1)}} \quad \text{(B.18)}$$

For the RS farmer, $A_1 = A_2 = 0$, for the RA farmer $A_1 = 1$ and $A_2 = 0$, and for the RN farmer, $A_1 = 0$ and $A_2 = 1$. The estimated models or functions for the three categories are as follows:

$$\text{RS:} \quad -1 + e^{-(\alpha_0 + \beta_2 X_i)} \quad \text{(B.19)}$$

$$\text{RA:} \quad -1 + e^{-((\alpha_0 + \alpha_1) + \beta_2 X_1)} \quad \text{(B.20)}$$

$$\text{RN:} \quad -1 + e^{-((\alpha_0 + \alpha_2) + \beta_2 X_1)} \quad \text{(B.21)}$$

α_1 is an estimate of the difference between a RS farmer and RA farmer and α_2 an estimate between a RS farmer and RN farmer. The intercept shifters are the deviations from the control (base) group.

The reason why the third dummy variable A_3 is not defined, is that if it takes the value 1 for RS and 0 for the others, then $\alpha = \alpha_0 + \alpha_1 A_1 + \alpha_2 A_2 + \alpha_3 A_3$, which is multicollinearity because $\alpha_1 A_1 + \alpha_2 A_2 + \alpha_3 A_3$ is always equal to 1, which is the constant term. This is known as the dummy variable trap. A way to avoid this problem is that the number of dummy variables is always one less than the number of categories (Ramanathan, 1992).

Annexure C

FARMER CHARACTERISTICS AND POSSIBLE PREDICTORS OF DIFFERENT ADOPTION GROUPS

C.1 Veterinary surgeon services

C.2 External parasite remedies

C.3 Internal parasite remedies

C.4 Antibiotics

C.5 Vaccines

(The possible predictors - $p \leq 0,15$ - are given in bold in each table)

C.1 VETERINARY SURGEON SERVICES

Table C.1: CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *VETERINARY SURGEON SERVICES* ADOPTION AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$) : *CONTINUOUS VARIABLES*

CONTINUOUS VARIABLES	A (n=51)	Pot/A (n=35)	N/A (n=13)	A & Pot/A (n=86)	Pot/A & N/A (n=48)	A versus Pot/A	Pot/A versus N/A	A versus N/A	A versus Pot/A & N/A	A & Pot/A versus N/A
Age of farmer (Mean years)	55	56	53	56	55	0,627[2]	0,490[2]	0,633[2]	0,856[2]	0,531[2]
Education level of farmer (Median grade)	6–7	<5	<5	6–7	<5	0,674[1]	0,991[1]	0,700[1]	0,620[1]	0,807[1]
Farming experience with livestock (Median years)	9	14	9	9	11	**0,069[1]**	0,843[1]	0,283[1]	**0,058[1]**	0,564[1]
Farming efficiency (Median weighted weaning percentage of small ruminants)	58	50	31	54	45	**0,079[1]**	**0,074[1]**	**0,015[1]**	**0,015[1]**	**0,021[1]**
Management skills – planning (Median days planned ahead)	309	61	100	136	90	**0,006[1]**	0,302[1]	0,251[1]	**0,040[1]**	0,840[1]
Level of entrepreneurship (Median score)	38	38	36	38	37,5	0,220[1]	**0,086[1]**	0,423[1]	0,521[1]	0,206[1]
Total livestock income per LSU (Median cattle, sheep and goat income Rand)	381	238	172	301	236	**0,002[1]**	0,618[1]	0,233[1]	**0,003[1]**	0,604[1]
Small ruminant herd size (Median number)	57	70	43	69,5	69,5	0,450[1]	0,531[1]	0,790[1]	0,624[1]	0,656[1]
Mortality rate in 1997 (Mortality as % of total small ruminant herd size – median [mean])	0 (1,23)	0,34 (4,4%)	0 (0,37)	0,16 (1,37)	0,11 (1,25)	0,286[1]	**0,054[1]**	0,266[1]	0,686[1]	**0,122[1]**
Extension officer visits (Median number per year)	4	2	4	3	2	**0,002[1]**	**0,090[1]**	0,518[1]	**0,005[1]**	0,730[1]
Sheep LSU's as % of total small ruminant LSU's (Type small ruminant farmer)	100	62	46	76	59	**0,149[1]**	0,223[1]	**0,047[1]**	**0,050[1]**	**0,077[1]**
Sample size	**51**	**35**	**12**	**86**	**47**					
Purpose of farming (Rated importance [1-4] for keeping small ruminants for normal farming)	2	3	2	2	3	0,265[1]	0,201[1]	0,705[1]	0,423[1]	0,456[1]

1. Mann-Whitney Test 2. t-Test

Table C.2: CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *VETERINARY SURGEON SERVICES* ADOPTION AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$) : *CATEGORICAL VARIABLES*

CATEGORICAL VARIABLES	A (n=51)	Pot/A (n=35)	N/A (n=13)	A & Pot/A (n=86)	Pot/A & N/A (n=48)	A versus Pot/A	Pot/A versus N/A	A versus N/A	A versus Pot/A & N/A	A & Pot/A versus N/A
Attitude towards risk						0,579[3]	0,481[4]	0,559[4]	0,639[3]	0,483[4]
Risk-seeking	43	43	62	43	48					
Risk-neutral	31	23	23	28	23					
Risk-averse	26	34	15	29	29					
Training sources to make specific decisions or attain information regarding medication usage						0,178[4]	0,650[4]	0,262[4]	**0,082[4]**	0,482[4]
Extension sources	61	60	46	60	56					
Co-farmers	22	11	15	17	13					
Books	4	0	0	2	0					
Self	14	29	38	20	31					
Record-keeping – Farmer keeping any kind of records	96	100	92	98	98	0,512[4]	0,271[4]	0,500[4]	1,000[4]	0,348[4]
Financial management – Farmer keeping income or cost records roughly or thoroughly	69	66	62	67	65	0,777[3]	1,000[4]	0,743[4]	0,670[3]	0,755[4]
Information-sources approached by farmer to make specific decisions:										
Technical decisions						0,784[4]	0,241[4]	**0,047[4]**	0,446[4]	**0,067[4]**
Extension sources	84	83	61	84	77					
Co-farmers	12	9	15	10	10					
Books	4	6	23	5	10					
Self	0	3	0	1	2					
Information on new technologies						0,972[4]	0,620[4]	0,626[4]	0,979[4]	0,500[4]
Extension sources	75	71	69	73	71					
Co-farmers	6	6	15	6	8					
Books	14	14	15	14	15					
Self	6	9	0	7	6					

CATEGORICAL VARIABLES	A (n=51)	Pot/A (n=35)	N/A (n=13)	A & Pot/A (n=86)	Pot/A & N/A (n=48)	A versus Pot/A	Pot/A versus N/A	A versus N/A	A versus Pot/A & N/A	A & Pot/A versus N/A
Farmer stating that specific external infrastructure is freely and easily available or accessible										
Roads	59	26	38	55	29	**0,002**[3]	0,480[4]	0,188[4]	**0,003**[3]	0,641[3]
Transport	22	6	0	15	4	**0,044**[3]	1,000[4]	1,000[4]	**0,010**[3]	0,207[4]
Telephone	14	6	8	10	6	0,300[4]	1,000[4]	1,000[4]	0,320[4]	1,000[4]
Farmer stating that specific institutions is freely and easily available or accessible										
Government and co-op extension and agricultural research	82	57	85	72	65	**0,010**[3]	**0,099**[4]	**0,100**[4]	**0,045**[3]	0,504[4]
Suppliers of inputs	47	17	23	35	19	**0,004**[3]	0,687[4]	**0,118**[3]	**0,003**[3]	0,535[4]
Old Qwaqwa (n=63) (% farmers) – location of farmers	57	77	54	65	71	**0,053**[3]	0,157[4]	0,854[3]	**0,149**[3]	0,539[4]
Farmer making use of any of the four mating seasons	78	71	69	76	71	0,458[4]	1,000[4]	0,856[4]	0,384[3]	0,733[4]
Breeding technology – farmer using registered or graded rams	62	71	25	67	53	0,452[3]	**0,023**[3]	**0,006**[4]	**0,076**[3]	**0,009**[4]

1. Chi-Square Test
2. Fisher's Exact Test

C.2 EXTERNAL PARASITE REMEDIES

Table C.3: CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF ADOPTION OF *EXTERNAL PARASITE REMEDIES* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$): *CONTINUOUS VARIABLES*

CONTINUOUS VARIABLES	Full & Over adopters (n=84)	Partial adopters (n=13)	F&O/A versus P/A (p-value)
Age (Mean years)	55	62	**0,043**[1]
Family size (Median numbers)	6	8	**0,105**[2]
Education level of farmer (Median grade)	<5	6-7	0,905[2]
Farming experience with livestock (Median years)	9	12	0,184[2]
Farming efficiency (Median weighted weaning percentage of small ruminants)	51	55	0,292[2]
Management skills – planning (Median days planned ahead)	120	365	0,488[2]
Level of entrepreneurship (Median score)	38	37	0,231[2]
Total livestock income per LSU (Median cattle, sheep and goat income [Rand])	271	308	0,498[2]
Herd size (median number of small ruminant herd [mean])	71 (123)	25 (64)	**0,064**[2]
Mortality rate in 1997 (Mortality as % of total small ruminant herd size – Median [mean])	0,11 (0,97)	0 (2,5)	0,472[2]
Indebtedness (Median amount [Rand])	0	25 000	**0,002**[2]
(Mean amount [Rand])	(13 188)	(39 323)	
Extension officer visits (Median number per year	3,5	2	0,831[2]
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	71	100	0,873[2]
Sample size	**83**	**13**	
Reasons of farming (Rated importance [1-4] for keeping small ruminants for normal farming)	2	2	0,916[2]

1 t-Test.
2 Mann-Whitney Test

Table C.4: **CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED ADOPTION OF *EXTERNAL PARASITE REMEDIES* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS (P≤0,15) : *CATEGORICAL VARIABLES***

CATEGORICAL VARIABLES	Full & Over adopters (n=84)	Partial adopters (n=13)	F&O/A versus P/A (p-value)
Attitude towards risk			**0,027**[2]
Risk-seeking	51	15	
Risk-neutral	25	31	
Risk-averse	24	54	
Literacy and arithmetic abilities	33	38	0,758[2]
Training sources to make specific decisions or attain information regarding medication usage			0,936[2]
Extension sources	58	54	
Co-farmers	17	23	
Books	2	0	
Self	23	23	
Record-keeping – Farmer keeping any kind of records	96	100	1,000[2]
Financial management – Farmer keeping income or cost records roughly or thoroughly	65	69	1,000[2]
Access to credit	63	62	1,000[2]
Information-sources approached by farmer to make specific decisions:			
Technical decisions			**0,047**[2]
Extension sources	83	62	
Co-farmers	11	15	
Books	6	15	
Self	0	8	
Financial decisions			0,625[2]
Extension sources	45	47	
Co-farmers	6	15	
Books	4	0	
Self	45	38	
Marketing decisions			0,841[2]
Extension sources	55	47	
Co-farmers	10	15	
Books	4	0	
Self	31	38	
Information on new technologies			0,796[2]

CATEGORICAL VARIABLES	Full & Over adopters (n=84)	Partial adopters (n=13)	F&O/A versus P/A (p-value)
Extension sources	70	84	
Co-farmers	7	8	
Books	16	8	
Self	7	0	
Farmer stating that specific external infrastructure is freely and easily available or accessible			
Roads	39	69	**0,069**[2]
Transport	10	23	0,164[2]
Telephone	12	0	0,394[2]
Electricity	2	8	0,354[2]
Local markets	49	92	**0,003**[1]
Farmer stating that specific external institutions is freely and easily available or accessible			
Government and co-op extension and agricultural research	70	92	0,175[2]
Suppliers of inputs	32	46	0,356[2]
Old Qwaqwa (n=63) (% farmers) – location of farmers	65	46	0,222[2]
Farmer making use of any of the four mating seasons	79	46	**0,035**[2]
Breeding technology – farmer using registered or graded rams	63	62	1,000[2]

1. Chi-Square Tests
2. Fisher's Exact Test

C.3 INTERNAL PARASITE REMEDIES

Table C.5: CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED ADOPTION *OF INTERNAL PARASITE REMEDIES* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$) : *CONTINUOUS VARIABLES*

CONTINUOUS VARIABLES	Partial adopters n = 70	Full adopters n = 12	Over adopters n = 15	F/A vs P/A	O/A vs P/A	F/A vs O/A
Age (Mean years)	54	63	55	**0,054**[1]	0,808[1]	**0,119**[1]
Family size (Median numbers)	7	9	6	0,414[2]	0,590[2]	0,209[2]
Education level of farmer (Median grade)	5,5	none	6-7	**0,049**[2]	0,953[2]	**0,123**[2]
Farming experience with livestock (Median years)	9	11,5	9	0,155[2]	0,707[2]	0,434[2]
Farming efficiency (Median weighted weaning percentage of small ruminants)	51	54	50	0,632[2]	0,397[2]	0,241[2]
Management skills – planning (Median days planned ahead)	152	65	100	0,255[2]	0,686[2]	0,730[2]
Level of entrepreneurship (Median score)	37	37	32	0,708[2]	**0,148**[2]	0,293[2]
Total livestock income per LSU (Median cattle, sheep and goat income [Rand])	282	304	493	0,948[2]	**0,114**[2]	0,242[2]
Herd size (median number of small ruminant herd [mean])	51,5 (106)	29 (128)	86 (145)	0,958[2]	**0,130**[2]	**0.011**[2]
Mortality rate in 1997 (Mortality as % of total small ruminant herd size – Median [mean])	0,07 (1,36)	1.04 (1.72)	0,12 (0,45)	**0,104**[2]	0,793[2]	**0,127**[2]
Indebtedness (Median amount [Rand])	0	0	0	0,373[2]	0,684[2]	0,639[2]
(Mean amount [Rand])	(19 590)	(9 000)	(9 313)			
Extension officer visits (Median number per year	3	8,5	2	**0,058**[2]	0,560[2]	0,188[2]
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	75	100	54	**0,059**[2]	**0,097**[2]	**0,003**[2]
Sample size	**70**	**12**	**14**			
Reasons of farming (Rated importance [1-4] for keeping small ruminants for normal farming)	3	2,5	1	0,822[2]	**0,085**[2]	**0,149**[2]

1. t-Test. 2. Mann-Whitney Test

Table C.6: **CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED ADOPTION OF *INTERNAL PARASITE REMEDIES* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \geq 0,15$) : *CATEGORICAL VARIABLES***

CATEGORICAL VARIABLES	Partial adopters n = 70	Full adopters n = 12	Over adopters n = 15	F/A vs P/A	O/A vs P/A	F/A vs O/A
Attitude towards risk				**0,082**[2]	**0,041**[2]	0,202[2]
Risk-seeking	40	42	73			
Risk-neutral	24	50	20			
Risk-averse	36	8	7			
Literacy and arithmetic abilities	34	25	40	0,742[2]	0,674[1]	0,683[2]
Training sources to make specific decisions or attain information regarding medication usage				0,247[2]	0,311[2]	0,720[2]
Extension sources	23	17	27			
Co-farmers	1	0	7			
Books	21	0	7			
Self	54	83	60			
Record-keeping – Farmer keeping any kind of records	96	100	100	1,000[2]	1,000[2]	-[3]
Financial management – Farmer keeping income or cost records roughly or thoroughly	60	92	80	**0,048**[2]	**0,144**[1]	0,605[2]
Access to credit	60	83	73	0,195[2]	0,333[1]	0,662[2]
Information-sources approached by farmer to make specific decisions:						
Technical decisions				0,331[2]	0,277[2]	0,188[2]
Extension sources	76	83	100			
Co-farmers	16	0	0			
Books	7	17	0			
Self	1	0	0			
Financial decisions				0,617[2]	0,905[2]	0,745[2]
Extension sources	41	50	53			
Co-farmers	9	17	7			
Books	4	0	0			
Self	46	33	40			
Marketing decisions				0,363[2]	0,376[2]	0,696[2]
Extension sources	50	75	67			
Co-farmers	16	0	0			
Books	4	0	0			
Self	30	25	33			
Information on new technologies				0,399[2]	0,533[2]	0,628[2]
Extension sources	70	75	87			

CATEGORICAL VARIABLES	Partial adopters n = 70	Full adopters n = 12	Over adopters n = 15	F/A vs P/A	O/A vs P/A	F/A vs O/A
Co-farmers	10	0	0			
Books	11	25	13			
Self	9	0	0			
Farmer stating that specific external infrastructure is freely and easily available or accessible						
Roads	49	42	33	0,658[1]	0,282[1]	0,706[2]
Transport	9	25	20	**0,122[2]**	0,192[2]	1,000[2]
Telephone	11	8	7	1,000[1]	1,000[1]	1,000[1]
Electricity	4	0	0	1,000[2]	1,000[2]	-[3]
Local markets	60	50	47	0,541[2]	0,343[1]	0,863[1]
Farmer stating that specific external institutions is freely and easily available or accessible						
Government and co-op extension and agricultural research	76	83	53	0,723[2]	**0,113[2]**	0,217[2]
Suppliers of inputs/outputs	40	25	7	0,521[2]	**0,013[1]**	0,294[2]
Old Qwaqwa (n=63) (% farmers) – location of farmers	59	67	80	0,754[2]	**0,120[1]**	0,662[2]
Farmer making use of any of the four mating seasons	70	92	87	0,166[2]	0,336[2]	1,000[2]
Sample size	**70**	**11**	**15**			
Breeding technology – farmer using registered or graded rams	56	73	87	0,343[2]	**0,026[1]**	0,620[2]

1. Chi-Square Tests
2. Fisher's Exact Test
3. Total separation.

C.4 ANTIBIOTICS

Table C.7: **CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *ANTIBIOTICS* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS (p≤0,15) : *CONTINUOUS VARIABLES***

CONTINUOUS VARIABLES	Full Adopters (n = 16)	Partial adopters (n = 69)	Non-adopters (n = 14)	F/A vs P/A	F/A vs N/A	P/A vs N/A
Age (Mean years)	66	56	55	**0,049**[1]	**0,043**[1]	0,377[1]
Family size (Median numbers)	8	7	6	0,718[2]	**0,065**[2]	**0,040**[2]
Education level of farmer (Median grade)	< 5	6-7	< 5	0,274[2]	0,352[2]	0,901[2]
Farming experience with livestock (Median years)	9	9	9	0,620[2]	0,950[2]	0,822[2]
Farming efficiency (Median weighted weaning percentage of small ruminants)	50	54	49	0,673[2]	0,647[2]	0,290[2]
Management skills – planning (Median days planned ahead)	274	120	258	0,357[2]	0,865[2]	0,391[2]
Level of entrepreneurship (Median score)	34	38	37	**0,008**[2]	**0,048**[2]	0,995[2]
Total livestock income per LSU (Median cattle, sheep and goat income)	R400	R260	R185	**0,053**[2]	**0,016**[2]	0,185[2]
Herd size (median number of small ruminant herd [mean])	50,5	106	112,5	0,486[2]	0,212[2]	0,334[2]
Mortality rate in 1997 (Mortality as % of total small ruminant herd size – Median [mean])	0,5 (2,57)	0,10 (1,15)	0 (0,16)	0,330[2]	**0,066**[2]	**0,133**[2]
Indebtedness (Median amount)	0	0	0	0,572[2]	**0,013**[2]	**0,023**[3]
(Mean amount])	R20 325	R18 751	0			
Extension officer visits (Median number per year)	4	4	1	0,489[2]	**0,026**[2]	**0,047**[2]
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	67	83	55	0,718[2]	0,255[2]	**0,136**[2]
Sample size	**15**	**69**	**14**			
Reasons of farming (Rated importance [1-4] for keeping small ruminants for normal farming)	3	2	1	0,170[2]	**0,028**[2]	**0,149**[2]

1. t-Test.
2. Mann-Whitney Test

Table C.8: **CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *ANTIBIOTICS* AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$) : *CATEGORICAL VARIABLES***

CATEGORICAL VARIABLES	Full Adopters (n = 16)	Partial adopters (n = 69)	Non-adopters (n = 14)	F/A vs P/A	F/A vs N/A	P/A vs N/A
Attitude towards risk				0,228[2]	0,224[2]	0,865[2]
Risk-seeking	25	48	57			
Risk-neutral	38	26	21			
Risk-averse	38	26	21			
Literacy and arithmetic abilities	31	33	36	0,873[1]	1,000[2]	1,000[2]
Training sources to make specific decisions or attain information regarding medication usage				0,448[2]	**0,069[2]**	**0,064[2]**
Extension sources	69	62	29			
Co-farmers	6	17	29			
Books	6	1	0			
Self	19	19	43			
Record-keeping – Farmer keeping any kind of records	100	96	100	0,1000[2]	-[3]	0,1000[2]
Financial management – Farmer keeping income or cost records roughly or thoroughly	56	45	43	0,180[1]	0,417[2]	0,971[1]
Access to credit	63	65	57	0,838[1]	0,765[1]	0,566[1]
Information-sources approached by farmer to make specific decisions:						
Technical decisions				**0,074[2]**	**0,090[2]**	0,366[2]
Extension sources	94	78	79			
Co-farmers	0	12	21			
Books	0	10	0			
Self	6	0	0			
Financial decisions				**0,066[2]**	0,282[2]	**0,001[2]**
Extension sources	31	51	29			
Co-farmers	19	4	21			
Books	0	0	21			
Self	50	45	29			
Marketing decisions				**0,039[2]**	**0,028[2]**	0,339[2]
Extension sources	81	52	36			
Co-farmers	6	12	14			
Books	6	1	7			
Self	6	35	43			

CATEGORICAL VARIABLES	Full Adopters (n = 16)	Partial adopters (n = 69)	Non-adopters (n = 14)	F/A vs P/A	F/A vs N/A	P/A vs N/A
Information on new technologies				0,397[2]	**0,139[2]**	0,510[2]
Extension sources	94	70	64			
Co-farmers	0	7	14			
Books	6	14	21			
Self	0	9	0			
Farmer stating that specific external infrastructure is freely and easily available or accessible						
Roads	63	46	14	0,245[1]	**0,007[2]**	**0,026[2]**
Transport	25	13	0	0,255[1]	**0,103[2]**	0,345[2]
Telephone	0	13	7	0,198[2]	0,467[2]	1,000[2]
Electricity	6	3	0	0,470[2]	1,000[2]	1,000[2]
Local markets	94	49	43	**0,001[2]**	**0,004[2]**	0,661[2]
Farmer stating that specific external institutions is freely and easily available or accessible						
Government and co-op extension and agricultural research	94	71	64	**0,104[1]**	**0,072[2]**	0,750[2]
Suppliers of inputs	38	33	29	0,751[1]	0,709[2]	1,000[2]
Old Qwaqwa (n=63) (% farmers) – location of farmers	56	58	100	0,900[1]	**0,007[2]**	**0,002[2]**
Farmer making use of any of the four mating seasons	69	75	79	0,752[2]	0,689[2]	1,000[2]
Breeding technology – farmer using registered or graded rams	50	63	71	0,329[1]	0,232[1]	0,761[2]

1. Chi-Square Test
2. Fisher's Exact Test
3. Complete separation

C.5 VACCINES

Table C.9: CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *VACCINES* ADOPTION AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS ($p \leq 0,15$) : *CONTINUOUS VARIABLES*

CONTINUOUS VARIABLES	Partial adopters (n=82)	Non-adopters (n=17)	P/A versus N/A (p-value)
Age (Mean years)	56	52.	0,378[1]
Family size (Median numbers)	7	6	0,255[2]
Education level of farmer (Median grade)	<5	6-7	0,536[2]
Farming experience with livestock (Median years)	9	9	0,477[2]
Farming efficiency (Median weighted weaning percentage of small ruminants)	51	52	0,616[2]
Management skills – planning (Median days planned ahead)	183	90	0,349[2]
Level of entrepreneurship (Median score)	38	37	0,522[2]
Total livestock income per LSU (Median cattle, sheep and goat income [Rand])	271	338	0,846[2]
Herd size (median number of small ruminant herd)	73	44	**0,112[2]**
Mortality rate in 1997 (Mortality as % of total small ruminant herd size – Median [mean])	0 (1)	0 (2)	0,830[2]
Indebtedness (Median amount [Rand])	0	0	**0,028[2]**
(Mean amount [Rand])	(19 741)	(12)	
Extension officer visits (Median number per year	4	3	0,914[2]
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	86	46	**0,003[2]**
Sample size	**82**	**16**	
Reasons of farming (Rated importance [1-4] for keeping small ruminants for normal farming)	3	1	**0,058[2]**

1. t-Test.
2. Mann-Whitney Test

Table C.10: **CHARACTERISTICS OF THE SAMPLE FARMERS CATEGORISED ON THE BASIS OF OBSERVED *VACCINES* ADOPTION AND STATISTICAL SIGNIFICANCE OF POSSIBLE PREDICTORS (p≤0,15) : *CATEGORICAL VARIABLES***

CATEGORICAL VARIABLES	Partial adopters (n=82)	Non-adopters (n=17)	P/A versus N/A (p-value)
Attitude towards risk			0,786[1]
Risk-seeking	46	41	
Risk-neutral	26	35	
Risk-averse	28	24	
Literacy and arithmetic abilities	35	33	0,851[2]
Training sources to make specific decisions or attain information regarding medication usage			0,732[1]
Extension sources	60	53	
Co-farmers	16	24	
Books	2	0	
Self	22	24	
Record-keeping – Farmer keeping any kind of records	96	100	1,000[2]
Financial management – Farmer keeping income or cost records roughly or thoroughly	71	66	0,706[2]
Access to credit	63	65	0,920[2]
Information-sources approached by farmer to make specific decisions:			
Technical decisions			0,320[1]
Extension sources	82	76	
Co-farmers	11	12	
Books	7	6	
Self	0	6	
Financial decisions			**0,011[1]**
Extension sources	49	23	
Co-farmers	6	24	
Books	1	12	
Self	44	41	
Marketing decisions			0,666[1]
Extension sources	56	47	
Co-farmers	11	12	
Books	2	6	
Self	30	35	

CATEGORICAL VARIABLES	Partial adopters (n=82)	Non-adopters (n=17)	P/A versus N/A (p-value)
Information on new technologies			0,668[1]
Extension sources	72	76	
Co-farmers	64	12	
Books	15	12	
Self	7	0	
Farmer stating that specific external infrastructure is freely and easily available or accessible			
Roads	48	29	0,171[2]
Transport	9	35	0,008[1]
Telephone	11	6	1,000[1]
Electricity	2	6	0,435[2]
Local markets	55	59	0,766[2]
Farmer stating that specific external institutions is freely and easily available or accessible			
Government and co-op extension and agricultural research	71	88	0,225[1]
Suppliers of inputs	35	24	0,346[2]
Old Qwaqwa (n=63) (% farmers) – location of farmers	56	100	0,001[1]
Farmer making use of any of the four mating seasons	74	71	1,000[1]
Breeding technology – farmer using registered or graded rams	62	59	0,824[1]

1. Chi-Square Tests
2. Fisher's Exact Test

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