ADOPTION AND USE OF TECHNOLOGY IN BEEF PRODUCTION IN THE SOUTH OF BRAZIL: A MULTIPLE-CASE STUDY INVESTIGATION OF FARMERS' ATTITUDES

A thesis presented in partial fulfilment of the requirements for the degree of Master of Applied Science in Agribusiness

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Abstract

In the last decade, the agricultural sector in Brazil has been undergoing significant structural changes as a result of the economic situation of the country and the modernisation process required by globalisation. The South of Brazil, after achieving status as a "zone free of foot-and-mouth disease", has enlarged its export market and faces new productivity requirements. It is assumed that increases in the rate of adoption of technologies in beef production can promote improvement in productivity and quality. The research aim was to identify farmers' attitudes towards adoption and use of technologies in beef production and their reasons for using/not using them. The purpose is to assist the increase in the rate of adoption of technologies in the Brazilian beef sector by the adequate formulation and recommendation of new technologies.

The study was conducted in the South of Brazil, using multiple-case study and qualitative analysis. Nine beef farmers were interviewed in Rio Grande do Sul, concerning the use of five technologies: artificial insemination, use of salt/urea, use of fertilisers and soil correction, parasite and disease control and soil testing. Rogers' five attributes of innovation were used as a framework for analysis and compared with farmers' perceptions of the technologies.

The research findings suggest that Rogers' attributes of innovations, although not all of the same importance, exert influence in the adoption decision. Farmers' very positive attitudes towards the adoption of new technologies was also identified. However, adoption and use of technologies are limited by financial constraints. It was concluded that further research and extension should focus on the financial and environmental circumstances of the farmers when developing and recommending the use of technologies, in order to increase the rate of adoption. Further research on this subject is suggested to confirm the study findings and to assist improvements in the sector.

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CHAPTER ONE

1 Introduction

The focus of the present research is the farm-level of beef production in Brazil. The study has been placed in the state of Rio Grande do Sul, in the very South of Brazil, for two reasons:

- Rio Grande do Sul is a State whose economy has been traditionally based in rural production and has beef production as one of the most important activities.

- The State has recently achieved status as a "zone free of foot-and-mouth disease with vaccination", opening the export market.

The investigation of farmers' circumstances and their attitudes towards technology formed the basis for the research with the objective of assisting future improvements in the area. Development and adoption of more adequate technologies could result in an increase in production and productivity. Increases in beef productivity and production has been a requirement for the recent market expansion. This study presents some aspects of Brazilian economy and agriculture to establish the context in which beef production and technology are inserted.

1.1 Background

Beef production in Brazil is going through a transformation and modernisation process. The changes reflect the search for new markets, with cost reductions associated to productivity and quality gains. It is assumed that a profitable agricultural activity is one that generates reasonable returns to maintain the producer and resources for new investments. The profitability in the beef production business in Brazil is decreasing, causing capital losses for the farmers. This situation has been resulting in the abandonment of the activity and, consequently, the reduction of the national herd (FNP 1998). The low gain of the activity shows the importance of the selection and adoption of technologies capable to associate good productivity with cost reductions.

In the last twenty years, an increase in costs and reduction in efficiency have been occurring. This is due mainly, to bad management of farms, the large size of properties and farmers unprepared for economic changes, showing a lack of planning. The increased costs caused by the cost of labour and mechanised operations, and the loss of soil fertility and pasture degradation lead to a decrease in productivity in the rural sector.

The beef production system in Brazil is based on extensive production: large areas with low cost and low productivity, using natural pastures. The extractive system has been also largely used in beef production. The extensive production, based on the extractive system, consists of the acquisition of extensive land areas with small capital to implant pastures to exploit with extensive beef cattle livestock. It was one of the most profitable businesses in Brazil between the decades of 1960 and 1990.

In the 60s, a farm in regions of fertile soil could be purchased for US$ 100 per hectare. The pastures were cultivated spending around US$ 200 per hectare. With the high natural fertility of the soil and the incorporation of nutrients from the native forest, it produced around 300 kg of live cattle/ha/year in the first years of exploitation. The system allowed the repayment of the investments in land (US$ 100/ha), pasture cultivation (US$ 200/ha) and animal acquisition (2 animal units (AU), US$ 360/ha) in three years of exploration, with a net return of 27 percent a year over the capital invested (animals and land) (FNP 1996). In this situation, it was more interesting to invest the profit in the acquisition of more animals and land than to maintain the productivity in the areas already explored. This system worked in the economic situation of the 1960s. However, there was a reduction in production because of the non-reposition of nutrients in the soil and beef production decreased around 6 percent a year. After twenty to 25 years of exploration, the production was reduced to 80 kg of live cattle/ha/year (FNP 1996).

In the 1970s, the introduction of new pasture types (*Brachiarias*) and governmental subsidies on the acquisition of machinery and opening of areas to agriculture, allowed the incorporation of large extensions of land ("cerrado"). That land, although low in natural fertility, did provide profitable results. The investments in land were the same (US$ 100/ha), with pasture cultivation cost of US$ 100/ha and animal acquisition cost of US$ 180/ha (1 AU). The return on the investments was made in around five years, with a net return of 15% a year over the capital invested (FNP 1996).

Apart from the high net return obtained from the activity in the extractive system, the farmers could gain with the increases in real land values of around 1,000 percent to 2,000 percent that occurred from the 1960s to 1990s. Currently, the situation has changed. The productivity is decreasing at a rate of 6 percent a year and the pastures have became degraded, producing from 50 to 80 kg of live cattle/ha/year and can stand only 0.5 to 0.7 UA/ha. The net return over the capital is only 1.4 percent a year (FNP 1996). Besides that, the increase in taxes on low productivity areas of land is another negative point to the business.

Livestock production in Brazil is responsible for 40 percent of the agricultural sector's total production. Although it is important to the national economy, little attention has been given to the sector during the last few decades. Governmental investments towards industrialisation to promote the economic growth occurred between the 1930s and the 1980s. This has lead to the impoverishment of the agricultural sector. In the last decade, less intervention from the government was part of a program to deregulate agricultural markets and eliminate direct price control. The decrease of investments and the opening of the economy are forcing the producers to search for efficiency and competitiveness.

Brazil has a natural advantage for cattle productivity given by the pasture land. However, there is a restriction to the improvement of herds which is the low content of protein in the pasture during winter (off-season period). It limits the cattle's weight maintenance and gaining. Imports are made to supply the demand during that period. Although the imports are not significant compared with the total production, they have increased significantly from 1971 to 1996, while production, exports and total consumption increased in smaller proportions (refer to Table 1.1). In 1997 imports decreased again (see Table 1.2) showing no apparent trend. Tight control on imports is over, and with Mercosur and deregulated import markets, imported beef is entering the domestic market and represents a competitor for the national beef. Brazils poor performance in beef production and trade liberalisation puts the national beef at a disadvantage in relation to other suppliers.

Table 1.1: Beef supply and utilisation in Brazil 1970-1996

(1000 Tons)

Year	Production	Imports	Exports	Total consumption	Per capita consumption (kg/Inh/year)
1970	1845	-	189	1656	18
1971	1838	6	219	1625	17
1972	1845	1	324	1522	16
1973	1786	1	237	1550	15
1974	1622	52	116	1558	15
1975	1790	24	113	1701	16
1976	2176	23	177	2022	19
1977	2446	39	190	2295	21
1978	2320	146	129	2337	21
1979	2114	144	105	2153	19
1980	2084	87	167	2004	17
1981	2112	83	283	1912	16
1982	2397	22	361	2058	17
1983	2360	26	457	1929	15
1984	2096	21	508	1609	12
1985	2223	48	537	1734	13
1986	1871	528	389	2010	15
1987	2137	164	321	1980	14
1988	2447	27	579	1895	14
1989	2748	188	345	2591	18
1990	2836	255	249	2842	20
1991	2921	112	335	2698	18
1992	3062	55	443	2674	18
1993	3124	20	453	2671	18
1994	3129	152	378	2903	19
1995	3703	114	288	3529	23
1996*	3888	130	302	3716	24

*Estimate

Source: Decex – Conab/Dipla/Depag/Diesp (in OECD 1997)

Table 1.2: Brazilian beef imports "in natura" per origin

(Tons)

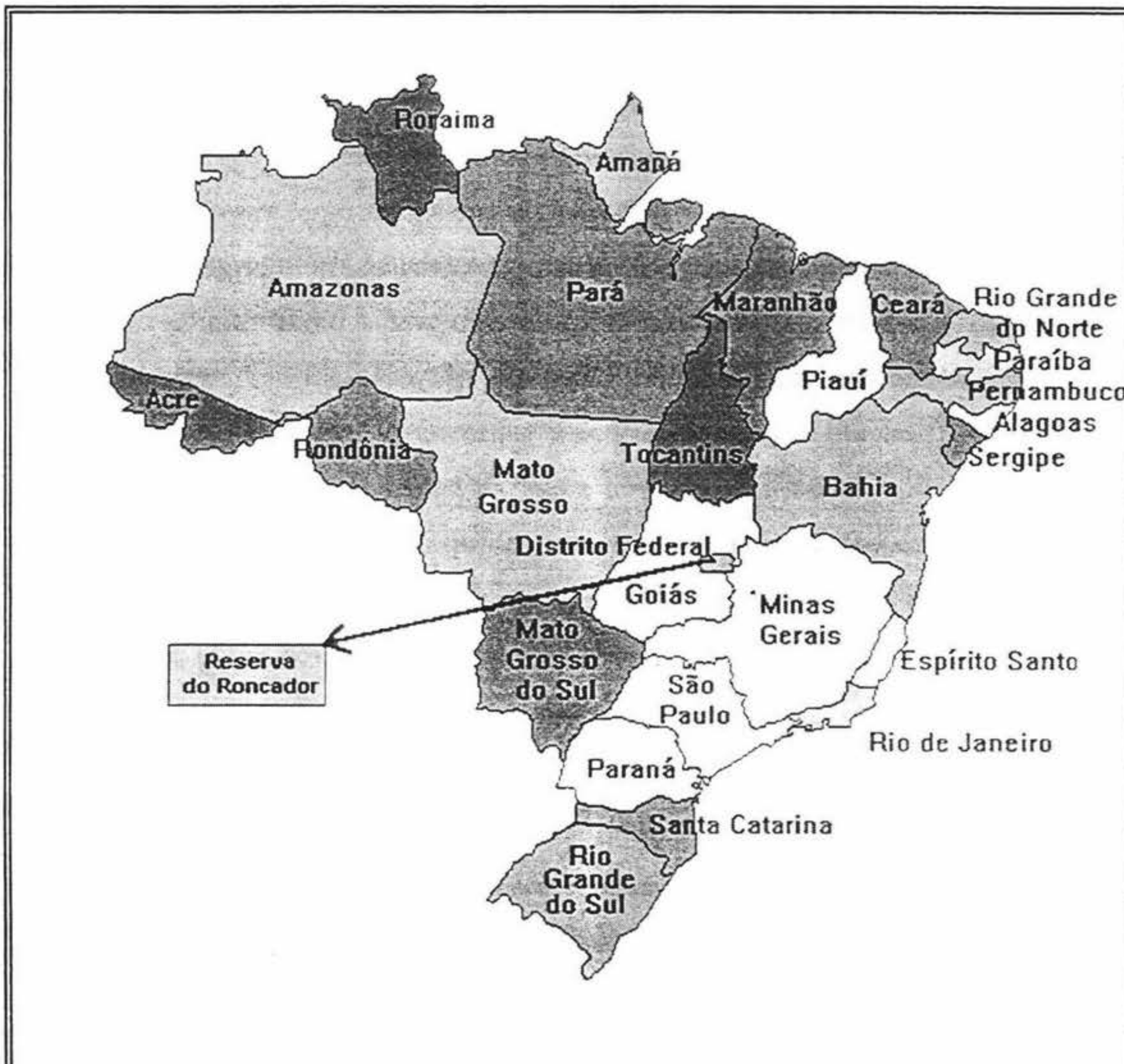
	1994	1995	1996	1997
Argentina	36,059	70,710	69,517	25,055
Uruguay	24,771	21,542	34,420	22,807
Paraguay	13,373	13,993	11,170	7,501
United States	224	725	2,234	2,994
Italy	262	160	0	96
Others	1,911	87	114	237
TOTAL	76,600	107,217	117,455	58,690

Source: FNP 1998

In summary, Brazil has a high imbalance between advancements in genetics, animal health, labour capability and farm facilities, on the one hand, and animal nutrition, on the other hand (OECD 1997). Urgent research into cattle production and management are required to promote improvements in these areas. Although there are gains in genetic improvement, the advances in animal nutrition are poor.

Rio Grande do Sul (RS) is a state that is in the Southernmost region of Brazil (see Figure 1.1), along with Paraná (PR) and Santa Catarina (SC). This region has been one of the most traditional beef producing and supplying regions in Brazil. RS, accounts for 60 percent of the regional herd, and 8.5 percent of the total Brazilian herd, and has one third of its area dedicated to beef production. The status achieved by the State as a "zone free of foot-and-mouth disease with vaccination" in 1997, was an important step towards the opening of new markets for export. However, RS' herd growth rates have been modest, and the last agricultural census (IBGE 1995/1996) showed abandonment of the rural activities in the State with a fall in the number of agricultural establishments and the occupied area (refer section 2.3).

Figure 1.1: Map of Brazil



Source: IBGE

1.2 Problem Statement

Brazilian agriculture has been following a production model related to the property of the land with a conception of wealth. The acquisition of land was done with the purpose of financial speculation. The owners were not exclusively farmers, but banks, brokerage agencies, agri-industries and multinationals enterprises. The consequences were large extensions of unproductive land. This misuse of the land impaired the agricultural activities by discouraging improvements in productivity. While the country did not have technology to produce beef, and the demand was growing faster than the offer, the extensive model of beef production, based in large properties with low investments, was feasible and profitable. In the 1980s, however, beef production started to face a new element: competition from other meats, especially chicken. The profit margin decreased and the sector started a period of capital losses, added to the loss of land value since 1994 with the introduction of the governmental financial plan (Plano Real).

The efficiency of the extensive production is decreasing, and less than 20 per cent of the 800 thousand beef producers are able to invest in a new pattern of efficiency. Beef production activity in Brazil is suffering deep changes in management and market, but still has not reached the efficiency of international standards of productivity. The need for restructuring and the opening of new markets requires an improvement in performance and an increase in productivity of the Brazilian agricultural environment.

Research and technology are important components of the productive process, being key factors to the agricultural development. In Brazil, research and technology for beef production are concentrated in genetic improvement and the benefits of pasture improvement have been ignored. Despite awareness of the beef supply shortage during the off-season, due to the variation of growth of pastures, very little attention has been given to this area. The adoption of inadequate technologies or even the non-use of technologies can be one reason for the poor performance of the sector. The identification of reasons of adoption / rejection and use of technologies is the focus of this research.

The adoption of adequate technologies demands the exact understanding of the financial and environmental circumstances, the farmers are faced with. Farming Systems Research (FSR) has been largely used in developing countries and the approach acknowledges the influence of the farmer on the operation of the farming system. To understand Brazilian farming systems it is necessary to identify farmers' circumstances, as well as their reasons for adoption / non-adoption of technologies in beef production in Brazil. This understanding can lead to better planning and development of technologies to meet farmers' needs.

1.3 Objectives of the Research

1. To determine the attitude of farmers towards adoption and use of technologies in the beef sector of Rio Grande do Sul.

2. To identify the reasons for adoption / non-adoption of technologies in beef production in Rio Grande do Sul.

1.4 Justification

The research purpose is to identify why technology is / is not adopted and used at farm level in beef production in Brazil. Brazil is the largest beef producer in South America and the third in the world. Constraints such as foot-and-mouth disease (FMD) and the large domestic demand have been limiting its beef exports. Rio Grande do Sul is a State devoted to agriculture, and its beef production represents 8.3 percent of Brazilian beef production . The recent status as a "zone free of foot-and-mouth disease with vaccination" has opened new market possibilities for the beef chain in Rio Grande do Sul, and indicates a need to increase beef production and quality.

Recent studies of the profitability of beef cattle farms (FNP 1996) have shown that the adoption of modern technologies in beef production improves the results in productivity and profitability. The Brazilian beef production in the extensive system, described in section 1.1 of this study, shows that the survival and growth of farms in the activity depend on investments in productivity. Investments in quantity and quality of pastures, good management and animal genetics are substantial factors in increasing production, which means the adoption of technologies.

It is assumed that the increase in adoption of technologies depends on the development and introduction of adequate technologies. Farmers are part of the process since their circumstances and behaviour determine the adoption decision. The importance of this research is to provide some knowledge to assist the achievement of higher rates in the adoption phase of the whole process of innovation-development. Knowing about farmers' perceptions and attitudes towards technologies and the factors influencing their decisions can be a tool to establish a pattern, and consequently, to achieve better results.

The agricultural sector in Brazil plays an important role for economic and social development. Farmers play an important role as managers, and the improvement of the sector that has been stagnant for the last few decades depends on them. The understanding of farmer financial and environmental circumstances, and their attitude towards technology adoption and use, can assist the development of adequate technologies, and the formulation of strategies to improve production and competitiveness. Increases in beef production, through adoption of current technology in Rio Grande do Sul, can improve beef sector performance.

1.5 Definitions

Some terms used in this thesis are defined in this section in order to provide precise meanings, and to avoid interpretations not compatible with the topic studied.

Productivity

"Productivity is a general term used to refer to the relationship between outputs and inputs", (Powell 1977, p.4.3). The total measure of productivity refers to the relationship between total output and total input use. It is measured by aggregating all inputs into some common measure and then calculating the input-output ratio. The larger the ratio, the greater the productivity. The higher the level of total productivity, the higher the economic return. Powell explains that what makes the total productivity concept useful is the relatively direct link between productivity and economic return. He argues that, apart from factors influencing prices for inputs and outputs, it is the productivity level that determines the economic return to resources used in the farm sector. Economic growth (measured as increased gross domestic product) is generated from two main sources: increased inputs and increased productivity. According to Powell, one of the sources of productivity growth, apart from better organisational structure and the minimisation of inefficiencies, is better technology. The author claims that improved technology is the easiest type of development.

Reason

" 'Reason' has a perfectly clear and precise meaning. It signifies the choice of the right means to an end that you wish to achieve. It has nothing whatever to do with the choice of ends" (Russell quoted in Nozick 1993, p. 64).

"Reason is wholly instrumental. It cannot tell us where to go; at best, it can tell us how to get there. It is a gun for hire that can be employed in the service of any goals we have, good or bad", (Simon quoted in Nozick 1993, p. 64).

Attitude

The importance of the concept of attitude is its role in guiding behaviour. It is assumed that attitude is a significant precursor and major determinant of behaviour. Attitudes usually play a major role in shaping behaviour (Engel, Blackwell and Miniard 1990).

Most definitions of attitude evident in the literature (Foxall 1983) can be aligned with the view expressed by Allport (1935):
"An attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related".

Another widely accepted definition of attitude is that of Fishbein and Ajzen (1975), where attitude is defined as a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object. They view attitude as part of a causal flow of behavioural dimensions that lead to the behaviour.

Innovativeness

"*Innovativeness* is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system", (Rogers 1983, p.22).

Extensive model

The extensive model of cattle production is based on large areas of land, with low cost and low productivity, using natural pastures.

Extractive system

The extractive system in Brazil used the deforestation of the tropical forest to expand the area available for agriculture. Cattle production in this system is done with the cultivation of pastures using the natural fertility of the soil and the incorporation of nutrients from the native forest.

CHAPTER TWO

2 Background and problem discussion

2.1 The Brazilian economy and agriculture profile

The growth of the Brazilian economy between the 1930s and 1980s reached rates considered amongst the highest in the world. Brazil changed, from an essentially agrarian economy, to an industrial economy, which is considered responsible for its growth. During that time, the government played a strong role with a policy bias in favour of industry, with a strategy of import substitution. Despite the development of the economy, Brazil remained a society with considerable inequality between classes and regions (Ferraz, Rush & Miles 1992). Currently, Brazil is in the process of reforming its economy, after 15 years of high economic instability, and trying to recover its rate of economic growth that has declined in the last years.

The agricultural sector in Brazil accounts for 14 percent of Gross Domestic Product (GDP), 25 percent of exports and 27 per cent of employment. Livestock production is responsible for 40 percent of the agriculture's total production. The sector employs more than 25 percent of the agricultural labour force, while crop production, on average, requires ten times more workers than livestock production. Brazilian livestock production is extensive, and occupies 200 million hectares of pasture land (OECD 1997).

In 1965, the "National System of Rural Credit" (Sistema Nacional de Crédito Rural – SNCR) was created. It brought regular credit support to the agricultural sector. The objective was to encourage the utilisation of the "modern inputs" produced by the new industry, and to increase production and productivity, making Brazilian products more competitive in the international market. However, high inflation at the end of the 1970s and the following decade made the credit to agriculture an excessive expense for the government, until 1984 when it was discontinued (Massuqueti 1997).

Agriculture in Brazil has exercised an important role during the economic crisis (foreign debt reaching US$ 100 billion) in the early 1980s, cushioning the impact of recession. Government policy regarding agriculture, until that decade, penalised the sector and frustrated the development of both domestic and export production. Agriculture's resilience until the end of the 1980s resulted from different factors. Two of them are, predominantly, the minimum price program, that reduced the risk to farmers and uncertainty about price expectations (Goldin & Rezende 1990), and the results of the investment in infrastructure and technology done during the process of modernisation in the 1960s (Massuqueti 1997).

At the end of the 1980s, however, the debt crisis resulted in more attention being paid to the need to ensure domestic food supplies and to agriculture's positive contribution to the balance of payments (Goldin & Rezende 1990). Several reforms were implemented in economic policy and reflected in the agricultural sector. Governmental measures towards agriculture of financing and purchasing a substantial amount of agricultural commodities were no longer practised, and in 1988 a stock release price mechanism was created, establishing ceiling and floor prices (OECD 1997).

In the beginning of 1990, measures were taken to deregulate agricultural markets and eliminate direct price control. The reform process included a severe cut in public funds to agriculture. Agricultural expenditures were reduced by 50 percent. Rural extension was extinguished or transferred to the States and funds were transferred to other areas, such as preservation of the environment, rural social programmes, education and health services. After 1993, the recurrent public deficits imposed severe restrictions on the resources destined for agriculture, with the withdrawal of the government from rural financial markets (OECD 1997). The new scenario of less government intervention in domestic markets forced the search for a greater efficiency and the need to become more competitive.

Since July 1994, with the introduction of a stabilisation programme and a new currency, the "Real", the Brazilian economy achieved more stability. The economic plan ("Plano Real") has been successful in controlling inflation and establishing the foundation for consistent economic development. Inflation has been reduced, and the President Cardoso has introduced political reforms, deregulation, and privatisation. Its transition from a state-dominated, protected economy, since 1990, to a free market, has opened Brazil to foreign competition and investment (Lima 1997). Agriculture, as well as the other sectors of the economy, is vulnerable to market forces, given the retraction of resources from the government. The production, marketing and financing of agriculture is attracting the private sector since the government's withdrawal. Currently, there is larger participation of the private sector in financing the rural sector than previously (Massuqueti 1997).

The participation of agriculture in the Brazilian GDP fell from 1955 to 1989, with rates switching from 23.5 percent to 7.7 percent. From 1989 to 1995, the participation of the agricultural sector in GDP increased from 7.7 percent to 13.2 percent. The change had three main causes: a better relation between inputs and outputs, an increase in production, and better relative prices between agriculture and industry (Bacha & Rocha 1997). Growth in agriculture has been maintained, as well as its importance in Brazilian economy. Due to the decrease in subsidies from the government, however, the agricultural sector today is suffering the consequences of reductions in expenditure on research and infrastructure.

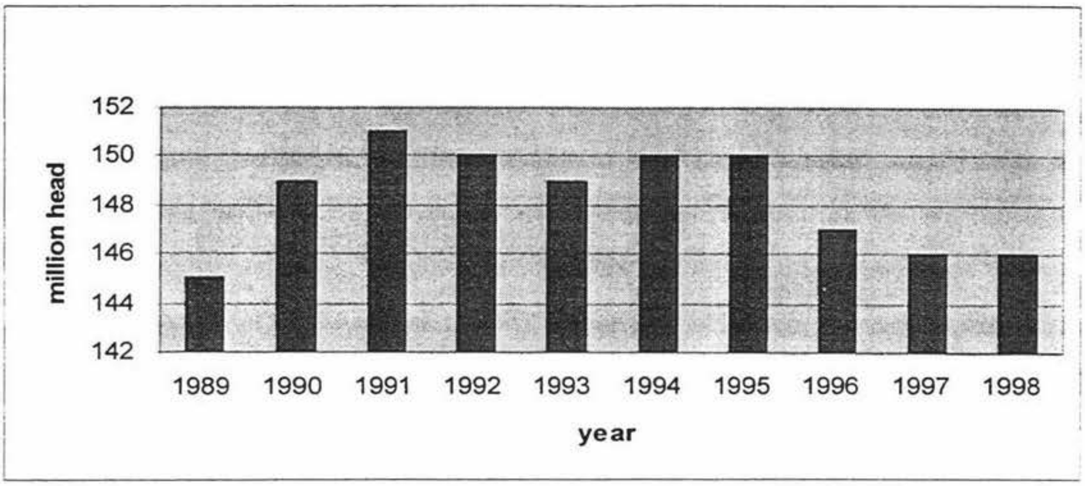
The challenge of the Brazilian food sector is to produce enough in quantity and quality to supply the domestic consumer market, which is expected to increase by 30 million over the next three years (Lima 1997). The sectors of the economy, both industrial and agricultural, are seeking modernisation in order to increase production.

2.2 The Brazilian beef sector

Beef cattle production started in Brazil at the same time of colonisation, with the importation of animals from the Iberian Peninsula. The main purpose was the production of leather, salted meat ("charque") and traction services. Only in the 1960s with the creation of the "Conselho Nacional de Desenvolvimento da Pecuária"(CONDEPE), a governmental program to develop cattle raising activity, did the sector start to change, increasing the productivity of the land and capital. In the 1970s, the introduction of *Brachiaria decumbens,* a type of pasture, as well as the governmental programs, stimulated the occupation of the land with cultivated pastures. From that period, the reduction of the displacement of livestock and the establishment of slaughterhouses gave technological and enterprising treatment to the activity. The farmer started to look for technology. Research about new kinds of pastures, animal nutrition, genetic improvement and reproduction, and sanitary management played a vital role in the process (Gramático 1996).

Brazil has the world's largest commercial cattle herd, with an estimated number of around 150 million head (see Figure 2.1). They are predominantly for beef production. Brazilian beef production is almost completely destined for the domestic market. Data from 1997 puts exports at 250,000-carcass tonnes/year that corresponds to 4.1 percent of total production (FNP 1997). The strong supply shortage during the off-season necessitates in the importation of beef from the neighbouring Mercosur and some European countries. Brazil is dependent on those imports to supply the domestic market and stabilise prices during the off-season months (OECD 1997).

Figure 2.1: Evolution of Brazilian livestock (1989-1998)



Source: FNP 1998

Besides the sanitary restrictions, the export market of agricultural products is limited by logistic difficulties and heavy restrictions imposed by North America. Brazil is estimated to be losing US$ 1.5 billion per year because of the restrictions imposed on agribusiness products (Jank 1997). One of the products most affected by those restrictions is beef. It is estimated that the trade agreements between the Americas would represent a potential gain of US$ 4.5 billion in agribusiness products export (Jank 1997). The recognition of the first two States, RS and SC, as free of foot-and-mouth disease, is starting to expand the export market.

As explained in Chapter One, section 1.1, "the traditional and still dominant beef production system in Brazil is an extensive, low cost and low productivity one, based largely on natural pastures" (OECD 1997, p.31). Most Brazilian beef production is characterised by "extensive" and "extractive" (refer to section 1.5, Definitions) with low indices of productivity. The pattern of Brazilian beef production is of stocking rates varying from 0.2 to two animals units (AU) per hectare. Calving rates range from 50 to 60 percent; mortality ranges from 15 to 20 percent; age at first calving is between three-and-a-half and four years; and the average slaughter age is four years, much higher than the pattern of high productivity systems. Brazilian cattle production is based on natural pasture, although the low content of protein in the pasture limits the animals weight gain during winter. The variation of pasture growth during winter determines the supply and price variation during that season, causing instability to the sector. Despite that, very little use is made of technology to establish a regular supply over the year (OECD 1997).

According to the OECD report (1997), in general, technology used in Brazilian beef farms is limited to the use of animal health products, the cost of which account for 7 percent of the variable costs of production. The highest costs are labour and management (accounting for over 50 percent), and transport (16 percent). The composition of the variable costs of Brazilian beef production is from typical extensive beef production with low input. The annual rates of growth of the cattle sector have been low in the last ten years (slaughter – 3.5 percent; beef production – 3 percent) compared with countries with the same potential for beef production (feedlot system with a rate of growth in the number of head of 12.7 percent). On the other hand, demand has grown 5.6 percent. Besides the low nutritive value of the natural pastures, the poor performance of Brazilian beef cattle production is due, mainly, to poor animal genetics and health, and inadequate herd management.

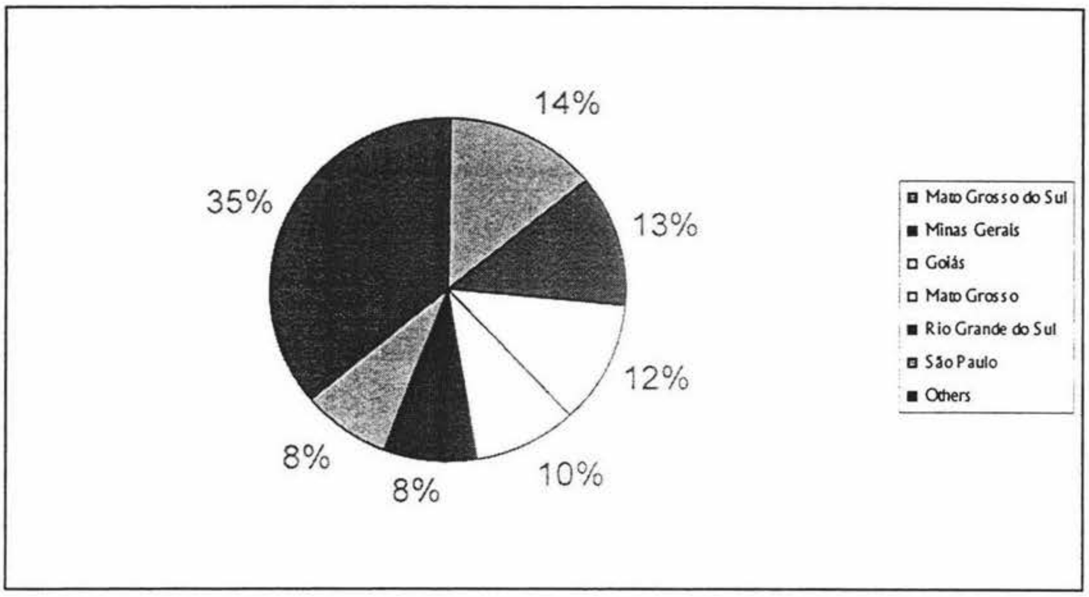
Concerning research and extension in the sector, research is moving slowly in the area of pasture improvement. "Farmers are frequently left without any guidance with regard to optimum levels of combination of feed mixes and herd size to be economically sound and profitable. Research and extension services are lagging behind in these critical areas of agricultural economics" (OECD 1997, p. 33). In addition, government programs are not well balanced. The emphasis given to genetic improvement was not being followed by health and nutrition research, achieving modest results (OECD 1997). The consensus is that research on cattle production and management is immediately needed, and it is indispensable to the process of market opening.

The high indices of clandestine slaughtering distort the real indices of production and consequently of the performance of the sector. The fragility of the internal market is responsible for the low beef prices, and discourages the adoption of modern technologies with the objective of improving the productivity (Gramático 1996). However, the increase in the Brazilian population and its meat consumption, due to the economic stabilisation and the globalisation effect, has compelled the beef sector to seek new techniques to result in more productivity. Because of the decrease in public resources and the world campaign for the environmental preservation, the areas for livestock production are not likely to increase. The total area of pastures will remain around 180 million of hectares, and it will be up to technology, the improvement of production to satisfy the demand (Gramático 1996).

2.3 Rio Grande do Sul beef sector

The South region of Brazil is the most traditional beef supplier to the domestic and international market. The State accounts for 8.3 percent of total Brazilian beef production (see Figure 2.2). The annual rates of herd growth of the region have been modest. In the periods of 1970-1975, 1975-1980 and 1980-1985, the rates were 2.57, 2.60 and 0.50 percent, respectively. RS accounts for 60 percent of the region's herd, and its rates of herd growth of the herd were 0.62, 1.93 and 1.92 percent in the same periods (Gramático 1996). The area of RS is 282,062 km2; one third of the rural area is dedicated to beef production. The activity is the most traditional economic activity of the region. Tables 2.1, 2.2 and 2.3 show data on beef production over the last few years in Brazil and more specifically, in RS and the other five most important States in the sector.

Figure 2.1:Brazilian cattle inventories (percent) per state (year 1998)



Source : derived from FNP 1998

Table 2.1: Brazilian cattle inventories per state

(1 000 head)

Year	Mato Grosso do Sul	Minas Gerais	Goiás	Mato Grosso	Rio Grande do Sul	São Paulo	Others (21 states)	Total Brazil
1994	20,597	19,338	18,201	12,692	12,831	11,995	53,661	149,315
1995	20,702	19,262	18,109	13,138	12,556	11,813	53,648	149,228
1996	20,297	18,735	17,681	13,362	12,163	11,403	52,469	146,110
1997	20,122	18,560	17,011	14,152	12,311	11,977	52,424	146,557
1998*	20,063	18,367	16,976	14,167	12,361	11,867	52,295	146,096

* Estimate

Source: FNP 1998

Table 2.2: Brazilian beef production per state

(1 000 Tonnes – carcass weight equivalent)

Year	Mato Grosso do Sul	Minas Gerais	Goiás	Mato Grosso	Rio Grande do Sul	São Paulo	Others (21 states)	Total Brazil
1994	602	586	643	348	477	1,012	2,053	5,724
1995	656	618	676	387	535	1,068	2,133	6,076
1996	729	663	711	418	539	1,108	2,202	6,372
1997	716	582	667	507	508	984	2,229	6,195
1998*	720	605	663	533	519	987	2,263	6,295

*Estimate

Source: FNP 1998

Table 2.3: Brazilian cattle slaughters per state

(1 000 head)

Year	Mato Grosso do Sul	Minas Gerais	Goiás	Mato Grosso	Rio Grande do Sul	São Paulo	Others (21 states)	Total Brazil
1994	3,038	3,038	3,241	1,704	2,315	4,573	9,928	27,837
1995	3,332	3,216	3,426	1,864	2,611	4,848	10,388	29,685
1996	3,749	3,493	3,656	2,006	2,678	5,070	10,871	31,523
1997	2,445	3,011	3,328	2,445	2,457	4,482	12,040	30,208
1998*	2,255	3,076	3,282	2,555	2,506	4,483	12,250	30,407

*Estimate

Source: FNP 1998

The cattle livestock in RS are grass fed on native pastures and are free of hormone growth promoters. In May 1998, RS along with SC, was recognised by the Epzootias International Organisation (EIO) in Paris, as a "zone free of foot and mouth disease with vaccination", after thirty years of efforts to combat the disease. The decision of the 151 countries that make up the EIO, opened the international beef market to Brazilian beef production, enlarging the prospects for export. Currently, RS beef exports amount to 2.5 thousand tonnes, less than 10 percent of Brazilian beef exports (FNP 1998).

The last agricultural census from 1995/1996 in Brazil (IBGE 1998) revealed that rural population of RS has decreased from 55 percent of total population, in 1960, to 21 percent, in 1996. The study shows a decrease in the number of small (10 to 100 hectares) and large (1,000 to 10,000 hectares) rural properties and an increase in medium sized (100 to 1,000 hectares) rural properties. The population employed in rural activities also decreased from 1.7 million in December 1985 to 1.3 million in the same period in 1995. The reduction is related to the modernisation process started in the 1970s. Given the high technology available for rural activities, agriculture demands increasingly less labour use.

According to the census, there is abandonment of rural activities in RS, revealing that the only people remaining in the agricultural sector are those who can invest in technology and increase productivity. The census also confirmed that there has been a fall of 13.5 percent in the number of agricultural establishments, and of 8.5 percent in the area used for agriculture. There was an increase in the number of landowners, and a reduction in the number of tenants, occupants and professional managers in the farm management activity (IBGE 1998).

Concerning the use of technology in rural properties in RS, the census showed the following results: as at 31/12/95 about 104.1 thousand (24.4 percent of the total) farms had tractors, a total of 159.074 units; 82 percent of farms used fertilisers in the 95/96 season; less than 48 percent of farms drew on technical assistance (37 percent of that was from governmental sources); and about 72 percent of farms had electricity. Only 17.3 percent of farms used bank loans to improve and expand activities.

CHAPTER THREE

3 Literature review

This chapter introduces, in the first section, some definitions of technology and discusses its importance and benefits in an agricultural system. It is important to define technology as it is the central issue in this study. The second and third sections describe the innovation-development and decision process, and outline factors affecting technology adoption. The use of technology in developing countries is discussed and the findings of researches conducted in those countries are mentioned.

The next sections comment on qualitative research, which was followed in this research, as well as the approach used in this study: multiple-case study. The techniques used to the research design and data analysis are also defined and commented on.

3.1 Definition of technology

Many definitions of technology are found in the literature. The definitions are complex and vary according to the context and purpose used. Basically, technology/innovation is conceptualised as something new. It may be a new product, a new process of production, the use of a new material, a reorganisation with the aim of improvement, or an improvement in instruments or methods of bringing about innovation. Rogers (1983) argues that the perceived newness of an idea, practice or object by an individual is what makes it an innovation. According to him, it matters little whether or not an idea is "objectively" new as measured by the lapse of time since its first use or discovery.

The importance of defining technological innovation is related to its central role in economic growth and improvements in efficiency. Since the focus of this research is related to technology and its effects on beef production improvements, it was considered fundamental to mention some definitions of technology suitable for the case studied. They are cited as follows:

"Technology is the software and hardware available for controlling the environment for human purposes" (Röling 1988, p. 12).

"Techniques which are systematic methods and procedures, involving people and 'hardware' utilised to achieve desired goals" (MoRST in Reid, Coulson and Cameron 1996, p. 5).

"A technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" (Rogers 1983, p. 12)

The common point is that technology is usually conceived as a benefit for the adopter. In agriculture, it is often seen as the key to raising agricultural output. Technology adoption can be associated with increasing and diversifying agricultural production and the generation of rural income and employment. Heeks (1995) argues that technological innovation provides solutions to developmental problems, and its implementation is a fundamental part of the development process.

3.2 The adoption of technologies

This section describes the process of technology adoption, and the attributes of innovations, defined by Everett M. Rogers (1983) in his book "Diffusion of Innovations", which was used as a framework for the data analysis in this research. It is important to note that the words "technology" and "innovation" are often used synonymously.

Diffusion is defined (Rogers 1983) as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p.5). "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 11).

The innovation-development process consists of a number of activities carried out until the adoption phase is reached. It starts from the recognition of a need or problem, followed by research, development, commercialisation, and diffusion. The last phases are adoption and consequences (Rogers 1983). Diffusion is a very crucial point in the whole process. The main problem is the decision of recommending technologies that will only have beneficial consequences to its adopters, and, sometimes, researchers and diffusers may not share a common perspective of the innovation. Diffusion involves the translation of the scientific findings into practice, and it may involve pressure to diffuse an innovation once a problem /need exists.

The decision process in the diffusion phase greatly affects the adoption phase that follows it. The decision of recommending a new technology by research/extension institutions can speed or retard the rate of adoption in a state or country. The example of no-till farming in the United States (Consumer Dynamics, Inc. 1980 cited in Rogers 1983) researched in the 1950s can illustrate this situation. The new technology was diffused early in the states of Virginia and Kentucky in the 1960s. However in Iowa, researchers and extension specialists opposed no-till farming for many years. In the 1970s, some Iowa farmers started to adopt no-till farming by reading about it in farm magazines. In the late 70s, the extension service started to provide information about the advantages of no-till farming technology, finally reaching the late adopters, and completing the diffusion process. The fact is that Iowa farmers were fifteen years behind those in the states of Kentucky, Virginia, Maryland and Tennessee, because Iowa State University was late in recommending the innovation.

The innovation–decision process is the "process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers 1983, p.20). The five main steps in the process are conceptualised as knowledge, persuasion, decision, implementation, and confirmation. Knowledge consists of the exposure of an individual to the innovation, and some understanding about it is gained in that phase. Persuasion is the phase when the individual forms a favourable or unfavourable attitude toward the innovation. The Decision phase occurs when the individual engages in activities that lead to the choice of adoption/non-adoption of the innovation. Implementation is when the innovation is put in use, and confirmation occurs when the individual reinforces his/her decision to use the innovation or reverses it.

The rate of adoption of an innovation is the relative speed with which potential users adopt an innovation. Innovations can be perceived differently by each farmer, according to their previous experiences, objectives and circumstances. The rate of adoption of an innovation is determined by the receiver's perceptions of its attributes. It is the perceptions of the receiver that influence his or her behaviour.

Fliegel (1993) argues that that a farmer's act of adoption is part of the diffusion process. Characteristics of the situation that affect that action, such as the size of the farm and farm income are included in diffusion studies. Farmers' personal characteristics are also taken into account. Tenure status, age or stage of family cycle, as well as level of education are significant characteristics that affect action with respect to innovations. Early studies about factors influencing the adoption of innovations among farmers (Fliegel et al. 1968, Wilkening et al. 1962, Hoffer 1942, Pedersen 1951 cited in Fliegel 1993) showed some other aspects involved in the innovation adoption process. Some of them are labour saving, rapid return on the capital invested, resource maintenance, profit maximisation, and cultural heritage.

The rate of innovation adoption can be determined by its attributes. They can help to predict farmers' adoption behaviour. The receivers' perceptions of the attributes of innovations will affect their rate of adoption. There are five different but interrelated aspects of an innovation, defined as the attributes of innovation. The attributes are criteria by which the new technology can be judged, and according to the ranking of each attribute, the technology will be more/less likely to be adopted. The five attributes are (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, (5) observability (Rogers 1983). Rogers (1983) defines them as follows:

Relative advantage, is the degree to which an innovation is perceived as being better than the idea it supersedes, which can be expressed in varying dimensions such as economic, social or other types. The economic profitability or social status to be gained from the adoption of the technology will affect the judgement of its potential adopter. Roger argues that, according to some diffusion studies, relative advantage can be one of the best predictors of an innovation's rate of adoption.

Compatibility is "the degree to which an innovation is perceived as consistent with the existing values, past experience and needs of potential adopters" (p.223). Here it is the potential adopter's socio-cultural values and beliefs, and previously introduced information or ideas that become important.

Complexity is related to the degree to which an innovation is perceived as difficult to understand and use. Roger argues that any idea can be classified on the complexity-simplicity continuum. The relationship between the perceived complexity of an innovation and its rate of adoption is indirect.

Trialability is the degree to which an innovation may be experimented with on a limited basis. The possibility of trial can increase the rate of adoption of the innovation, once the uncertainty about the consequences is reduced.

Observability is the degree to which an innovation's results are visible to others. As defined by Rogers, a technology has two components that vary in its composition: the hardware aspect that consists of the material or physical aspect, and the software aspect that is the information base for the technology. As the software aspect is less visible, technologies consisting predominantly of the software aspect have a lower or slower rate of adoption than technologies predominantly composed of the hardware aspect.

Those attributes of innovations form a largely accepted framework to explain the adoption of innovations and they will be used as a reference in the analysis of the cases studied in this thesis.

The adoption process is not always successful. In many cases, the users do not reach the intended level of use, or the technology is rejected because it does not fulfil the expectations. The adoption success depends on the way that the components of the technology interact with the adoption context (Léon 1996).

3.3 Technology adoption in developing countries

The adoption of agricultural technologies in developing countries is a topic of concern in many development projects. The reason is that a large proportion of the population of those countries derives their livelihood from agricultural production, and technology adoption is a means to increase that production. However, the introduction of new technologies has been constrained by a number of factors, not only economic but social as well.

Feder, Just & Silberman (1981), in a paper prepared for the World Bank, surveyed various studies which investigated factors affecting adoption of new technologies in agriculture in less developed countries. They commented that factors, such as: lack of credit, limited access to information, inadequate farm size, inadequate incentive associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortages, chaotic supply of complementary inputs and inappropriate transportation infrastructure, are constraints to the adoption of new technologies.

The findings according to the studies cited in that paper (see table 3.1) are: that farm size is directly related to the rate of technology adoption as confirmed by the studies of Gemmil (1972), Weil (1970) and Binswanger (1978). At the same time, other studies suggest that large farms become a constraint to the adoption of certain technologies (Greene 1973, Alviar 1972). Tenure arrangements were not found to be a significant variable in accounting for variation in adoption (Muthia 1971, Blanckenburg 1972, Castillo 1973, Colmenares 1975, Gafsi 1976). Labour availability is a factor that varies depending on the technology to be adopted. Some new technologies are labour saving, and others are labour using (Hicks & Johnson 1974, Harris 1972, Helleiner 1975, Norman 1969).

Access to capital, either in the form of savings or capital market, was found to be an important factor affecting the adoption of innovations (Lipton 1976, Bhalla 1979, Lowdermilk 1972), showing that the lack of credit and differential access to credit are significant constraints on adoption (Gotsch 1972, Havens & Flinn 1975). Other factors such as risk, uncertainty and human capital, as well as sociological factors, are identified as important variables that influence technology adoption. A significant relationship was found between farmers' choices and their exposure to information regarding new technology, which is supported by the hypothesis that more exposure to appropriate information through various communication channels reduces subjective uncertainty (Gafsi & Roe 1979, Rogers 1969). In addition, education was found to be an important factor affecting adoption behaviour (Chaudhri 1973, Harker 1973, Mook 1973, Wu 1974, Haller 1972, Evenson 1973, Lockheed, Jamison & Lau). A significant relationship between education indicators and farm productivity has been shown.

In a study done in Tetu by Röling in 1970 and 1973 (Röling 1988), some similar variables were found associated with innovativeness among farmers. Education was strongly linked to the degree of innovative behaviour, shown by the fact that the most innovative farmers were the ones who most encouraged education in their families. Literacy showed a similar pattern. Social status associated with income was also shown to have a direct relationship to the degree of innovativeness. Farm size in the study was found to be directly related to innovation: the larger the amount of land, the higher the degree of innovativeness. Cosmopolitaness, or geographic mobility, as well as mass media exposure were also directly associated with farmers' degree of innovativeness.

The importance of establishing a pattern of behaviour among farmers, through the identification and analysis of target categories, is to reduce variability and save time and money on research when introducing a new technology. Röling (1988) considers it a necessary condition for targeting technology and packages of inputs, and a necessary condition for solving some of the most pressing development problems.

Table 3.1: Factors affecting the rate of adoption of technologies in agriculture in less developed countries

Relationship / Factor	**Direct relation** Increase in factor ↑ ↑ Increase in rate of adoption	**Indirect relation** Increase in factor↑ ↓ Decrease in rate of adoption	**Does not affect the rate of adoption**
Farm size	x	x	
Tenure arrangements			x
Labour availability	x	x	
Access to capital	x		
Risk and uncertainty		x	
Human capital	x		
Exposure to information	x		
Education	x		
Accessibility to marketing network	x		
External off-farm income	x		
Availability of complementary inputs	x		

Source: derived from data in Feder et al. (1981)

Developing countries face difficulties related to existing scientific and technological infrastructure. Research in this area is done with the aim of making a profit and is oriented to high-value products for the domestic and overseas market (Galhardi 1995). It is argued that much of the research conducted in developing countries, including Latin America, is not really relevant to the needs of the country. There is serious disassociation between Science and Technology (S&T) practices and prevailing political priorities, social preoccupations and cultural modes (James 1990). James (1990) suggests that science, technology and policies must be intimately interconnected. Ayre-Smith (1976) argues that when attempting to introduce innovations in developing countries, three problems are often encountered: lack of entrepreneurs, shortage of people with appropriate managerial and technical skills and the choice of appropriate innovations.

Increasing the efficiency of beef production in developing countries includes the removal of impediments of price control, taxation, land tenure, lack of regulations and optimisation of the marketing chain. It also includes provision of services such as, disease control, education, operational agencies, provision of breeding stock, material and incentives, credit and infrastructure, and the use of innovations (Ayre-Smith 1976). The beef cattle farmer has a variety of innovations available to improve the efficiency of his enterprise, however, without adequate information, the choice may not produce the desired results. On the other hand, farmers in some developing countries have not adopted technologies recommended by research programs, often because these technologies are not consistent with their circumstances (Byerlee, Harrington & Winkelmann 1982). Those technologies are often developed in research stations without the involvement of farmers. Technology design should be done through the identification of important opportunities and then the development of technological alternatives given the farmers circumstances.

The traditional models for agricultural research and extension, the Transfer of Technology (TOT) and Diffusion models, are less concerned with the involvement of end users in the research process (Chambers and Ghildyal 1985). Technology is treated as something generated by researchers and given to the farmers. The Diffusion model considers that the process of technology diffusion occurs from researchers to innovators and more slowly to the less innovative farmers. Both models consider that the understanding of the whole farm can be obtained from the individual components, and limited attention is given to the farmer's role in a farm's performance (Reid 1996).

Farming Systems Research (FSR) is an alternative approach to understanding farming systems and the relationships within that environment. It is a participatory method for developing technology. It emphasises the importance of collecting information from and about farmers, before designing technology and while testing it (Röling 1988). It has emerged in the last two decades in less developed countries as an approach to improve the living standards of rural communities. The objective of FSR is not only to achieve a high level of productivity through technology implementation, but also to allocate the benefits to all components of the system, and develop a full knowledge of the whole system, taking into consideration the significant influence of the farmer and farm family goals in the process. The researcher in this model has a role different from the traditional. Researcher and farmer are encouraged to develop a partnership, with the recognition of knowledge and expertise of both seen as valuable to the research process (Reid 1996).

Röling (1988) emphasises the importance of knowledge and technology as the major determinants of development. He argues that technology development increasingly drives agricultural development, and the effect of technology-driven development is felt through competitive market pressures. Once technology–driven development takes off, the market forces will manage the agricultural system. The diffusion of technology and competition will follow a natural course. The introduction of a new technology can lead to the improvement of agricultural output and efficiency. It will result in lower farm gate prices and market pressures to innovate in order to remain competitive. Hence, some of the advantages of technology-driven development are: the enhancement of competitiveness and the relatively small effort needed to lead to the rapid diffusion of new technology, since the price mechanism will pressure for efficiency.

3.4 The qualitative research

This research followed a qualitative approach. Given the complex nature of the object studied, the focus on attitudes and reasons to explain the behaviour of adoption/non-adoption of technologies, the interpretation of meanings was considered more appropriate than a statistical analysis. The study refers to a developing country, where farmers are facing socio-economic problems that affect their rural environment. The use of a qualitative approach in this study attempts to explain factors determining farmers' circumstances and behaviour instead of simply verifying their occurrence. Definitions and arguments from the literature were used in the following sections to support this idea and the techniques used in this research.

Qualitative research means an approach to knowledge production; it does not refer only to data. Words and their meanings are the focus of research, even when they are codified as numbers (Tesch 1990). Qualitative research design, according to Janesick (1994), begins with a question. That is one of the aspects that differentiate the qualitative study from the quantitative. The questions to be answered are quite different. Qualitative research begins with a search for understanding of the whole.

Erickson (1986) states that "what makes qualitative research interpretative or qualitative is a matter of substantive focus and intent, rather than of procedure in data collection, that is, a research technique does not constitute a research method" (p.119-120, quoted in Janesick 1994, p.213). The meanings of the actions of the actors involved are of central interest.

One of the major features in qualitative research is its focus on naturally occurring, ordinary events in natural settings. Another feature is the richness and holism of qualitative data, with strong potential for revealing complexity (Miles and Huberman 1994). Qualitative research goes beyond questions like "what?" or "how many?" It can explain how and why things happen. The researcher is interested in the process, meaning and understanding gained through the data collected (Creswell 1994).

Van Manen (1977, cited in Miles & Huberman 1994, p.10) claims that "qualitative data, with their emphasis on people's "lived experience" are fundamentally well suited for locating the *meanings* people place on the events, processes, and structures of their lives: their perceptions, assumptions, prejudgements, presuppositions, and for connecting these meanings to the *social world* around them".

In rural research, Moris and Copestake (1993) advocate that rural data obtainable in developing countries is more likely to merit qualitative than quantitative treatment. There are many problems emerging in those countries associated with too specific approaches to be quantified. They suggest that qualitative approaches are more appropriate to deal with rural data.

3.5 The multiple-case study

Stake (1994) argues that the "case study is not a methodological choice, but a choice of object to be studied" (p.236). The researcher may focus on a single case or a number of cases, what Stake defines as the collective case approach. The cases are analysed in terms of specificity and generic properties. Case studies attempt to investigate the relationship between the particular characteristics of the object studied and its context; the study takes a holistic approach to data collection.

Qualitative studies usually work with a small sample of people nested in their context and studied in-depth. The samples tend to be purposive rather than random. The sampling process involves defining aspects of the case(s) to be studied within the limits of time and means available. It also involves creating a frame to guide the findings, confirmation and qualification of the constructs from the study (Miles & Huberman 1994). According to Firestone (1993), the most useful generalisations from qualitative studies are analytic, not "sample- to-population".

"Multiple-case sampling adds confidence to findings" (Miles & Huberman 1994, p.29). The precision, validity and stability of the findings can be strengthened. However, even using a number of cases, the generalisations can not be made for populations as in quantitative samples, because the choice of cases is made on conceptual grounds, not on representative grounds. The number of cases that should constitute the sample in a qualitative multiple-case study is not definable. The adequate number of cases will depend on how rich and complex the sampling is.

In the collective or multiple-case study, the researcher may study a number of cases in order to investigate a phenomenon, population or general condition. The individual cases may or may not be known in advance to manifest the common characteristic; they may be similar or different. "They are chosen because it is believed that understanding them will lead to better understanding, perhaps better theorising, about a still larger collection of cases" (Stake 1994, p. 237).

Maxwell (1986) advocates that case studies can play an important part in the rural research toolbox. Since time and cost are two main constraints, it is necessary to choose a suitable research method. Case studies provide an optimal combination of time, cost accuracy and coverage characteristics. Its low coverage can be outweighed by the benefits. Given the complexity or cost of data collection usually found, the case study can provide an appropriate practical approach because it can provide low cost in high level of information. Case studies are a good method of investigating causality, the interrelationships between people, to establish and explain current attitudes and beliefs, and to show why certain behaviour occurs (Casley & Lury 1982, cited in Maxwell 1986).

Because the research project's objectives involve people, the interrelationship between them, their characteristics and their interaction with the environment, the multiple-case study was considered the most suitable method of investigation the situation. It can provide high level of information in a small sample. Also the geographic and time constraints present in this study led to a method that could obtain the most from a small number of cases.

3.6 Quantitative data in qualitative research

There is strong debate between the supporters of quantitative and qualitative research (J. K. Smith 1983; J. K. Smith & Heshusius 1986; Reinharz 1993; Gherardi & Turner 1987, cited in Miles & Huberman 1994). Qualitative research is accused of being a "soft" social science, interested in "mushy" processes, and dealing with inadequate evidence, while quantitative research is considered to be hard-nosed, data-driven, outcome-oriented, and truly scientific (Yin 1993). However, in the middle ground, it is recognised that both numbers and words are useful to understand the world. Kaplan (1964, cited in Miles & Huberman,) claims that quantities are of qualities, and a measured quality has just the magnitude expressed in its measure. Also Weinstein and Tamur (1978) see quantification not as an end in itself, but rather as a means of making available techniques which add power and sensitivity to individual judgement when one attempts to detect and describe patterning in a set of observations.

The linking of qualitative and quantitative data is suggested (Rossman & Wilson 1984, 1991, Greene, Caracelli & Graham, 1989, cited in Miles & Huberman 1994; Firestone 1987) for many reasons: confirmation and support of each other (triangulation), elaboration and development of analysis and as a source of new ideas through unexpected findings. Also, quantitative data can help the qualitative study by finding a representative sample, locating deviant cases during design, supplying background data, obtaining overlooked information, and avoiding "elite bias" during data collection. During analysis, quantitative data can help by showing the generality of specific observations and verifying qualitative findings (Sieber 1973).

According to Madey (1978, cited in Miles & Huberman 1994), the methods, quantitative and qualitative, are not always interchangeable, but one can be strengthened by using the intrinsic qualities of the other. Miles and Huberman (1994) state that the careful measurement, generalizable samples, experimental control and statistical tools of good quantitative studies combined with the up-close, deep, credible understanding of complex real-world contexts of good qualitative studies, is a powerful mixture.

From the discussion above it is possible to perceive the usefulness of both quantitative and qualitative data. Being prisoner of only one methodology would only reveal a narrow-minded behaviour. The researcher should make use of any resource available that could help to achieve better results in the research. Each research will present different needs according to the circumstances under which it is being conducted, and it must be considered when choosing one or other method, or both.

3.7 Matrices

Qualitative data in the form of field notes, transcriptions, or text can become very difficult to analyse, given their complexity and the diversity of means by which they can be analysed. In the process of qualitative analysis a number of means to simplify data (Miles & Huberman 1994, Dey 1993, Coffey & Atkinson 1996) have been suggested to make them suitable for analysis. When dealing with complex and voluminous data it is helpful to use a method of data display to present the results in a coherent and intelligible form (Dey 1993).

Matrices are a method of data display that involve the crossing of two or more main dimensions or variables to see how they interact (Miles & Huberman 1994). The information can be summarised and concentrated in an organised and focused way. It can improve the understanding of the whole, and will require having in mind all the steps taken to decide about the matrix's focus and its relationship to the research objectives or questions. The inclusion of a display in a final report will allow a re-creation of the analysis reasoning by another person. However, matrices have no fixed rules for construction. The main objective of a matrix is to give answers to the questions asked, and be helpful to the understanding of data.

Matrices can be used during data collection and/or at the later stages of analysis. The lack of details in the data generated with the use of matrices during data collection will be compensated by the minimisation of researcher bias, once data is supplied direct from the interviewee. Rows and columns represent elements and constructs. The elements may be a group of subjects, and the constructs are descriptions of the interviewee's perception of the elements (Hill 1993, cited in Coulson 1996). Numbers can be introduced as a means of data reduction, assigning categories to it. It is possible to enumerate qualitative decisions and relate them to numbers. "The virtue of reducing values and variables is that we can increase the focus of our analysis" (Dey, 1993, p.201).

Matrices in a multiple-case study can be used to compare information across cases. Data organised in matrices can produce a useful overview of the main features of each case. The cases can be compared more effectively, and it is possible to look for possible singularities, regularities and variations within the data (Dey 1993).

Matrices, in this research, will be used as a tool to simplify and give more precision to the answers, avoiding bias. The distance between researcher and interviewer and interviewees was a problem faced in this research. To compensate for that, all the available tools were used in order to preserve the focus and to avoid the loss of information. Matrices were considered a valuable tool in this study.

3.8 Qualitative data analysis

Tesch (1990) claims that there is no right way to analyse qualitative data. "Data analysis requires that the researcher be comfortable with developing categories and making comparisons and contrasts" (Creswell 1994, p.153). Qualitative data are collected through observation, interviews or documents, and those activities are carried out in close proximity to the local setting during a period of time (Miles & Huberman, 1994). The data collected are not usually immediately accessible for analysis. They require some processing, that means to be put in codes or organised in such way that they can be more easily studied.

Authors describe the qualitative data analysis process in various steps, Tesch (1990) considers eight steps from the reading of transcriptions to coding categorisation; while other authors reduce it to two or three steps. Marshal and Rossman (1989) establish the process in two steps: reduction and interpretation. Dey (1993) defines three steps in qualitative data analysis: description or examination, classification or categorising, and connecting and tabulating.

Similarly to Dey, Miles and Huberman (1994) establish three basic activities in qualitative analysis: data reduction, data display and conclusion drawing / verification. Data reduction is the process of simplifying data from its raw condition. The objective is to focus, abstract and transform information from the field notes. Data reduction sharpens, sorts, focuses, discards and organises data to make possible the drawing of conclusions and verification.

Data display is an organised way of compressing and assembling information to permit easier conclusion drawing, as it shows data more clearly and objectively. Also, it avoids overweighing information, provides more justified conclusions and founded ideas, making stronger the validity of qualitative analysis. Data display is not a separated process from analysis, but an activity that makes part of it.

The third activity, defined by Miles and Huberman (1994), is conclusion drawing and verification. Conclusion drawing consists of "noting regularities, patterns, explanations, possible configurations, causal flows and propositions" (p.11). Verification can be as brief as a second thought across the conclusions and back to the field notes, or it can be done through argumentation and review including discussion with other people. In brief, it is the confirmation of the meanings emerged from data, their validity.

Qualitative data analysis needs to be well documented in its process, including data, the explanation of the codification, the interpretation of the meanings and connections made during the analysis. The documentation of the steps followed is necessary to make it usable by other researchers.

CHAPTER FOUR

4 Methodology

4.1 Questionnaire design

The questionnaires were structured as simply as possible in order to provide precise answers. The first part of the interview was "Questionnaire 1"(refer Appendix). This part was concerning the farmers' personal data, as well as some personal background. It also included general farm data: size and the locality of the farm, number of employees, area and type of pastures, number of head, main activity and livestock data. Farmers' goals and objectives in the short and long term were asked.

The second part of the interview, "Questionnaire 2"(refer Appendix), focused on five technologies and the farmers' situations and opinions about them. The technologies were selected through readings in Brazilian publications about beef production and conversations with a farm consultant and a farmer. Both are Brazilians and have more than five years experience in farm consultancy and farming, respectively. The criteria for technology selection were: technology used for more than five years in Brazil, easily understandable and recognisable, and related to livestock improvement (genetics, health or nutrition) or pasture improvement for beef production. The selected technologies were: artificial insemination, use of salt plus urea, use of fertiliser and/or soil correction, parasites/disease control and soil testing.

For the questions 1 and 2 of Questionnaire 2, matrices were created to simplify the questions and for better visualisation of the relationship between the user's situation/opinion and technology. In question 1 the situation of the farmer in relation to the five selected technologies was asked. The possible situations of use were listed and displayed in columns and crossed with each technology displayed in rows. The situations listed were: current use, have used but do not use currently, never used, and rejected at first but now use the technology. The length of use time and reasons for use were also asked.

In question 2 of Questionnaire 2 a matrix was used crossing eight constructs and the five selected technologies. The constructs were created from Rogers' five attributes of innovations. Each construct has a relationship with the meaning of one of the five attributes. The constructs "cost" and "financial benefit", "time and labour" and "herd management" are related to the "Relative advantage" attribute. "Risk" refers to the attribute "Trialability". The construct "compatible with objectives" is related to the attribute "Compatibility". "Complexity and flexibility" refer to the attribute "Complexity". Finally, the construct "visibility of results" is related to the attribute "Observability". A space for comments was added at the end of the matrix.

A scale from 5 to 1, strong advantage to strong disadvantage, was used to classify each construct in relation to each technology, in order to express the constraints and opinions of the farmers about the technologies. An extra column was added to the matrix to allow the inclusion of any other construct that the farmer could consider relevant. In the last column of the same matrix, a space to rank the five technologies according to the relevance of use in the farm was added, from 1 (most important) to 5 (less important).

Questions 4 and 5 of Questionnaire 2 refer to farmers' interests in other technologies different from the five listed in the matrices. The reason for the interest was also asked. Question 5 is a space for additional comments.

The questionnaire was first designed in English, and it was modified until reaching the final format. The next step was the translation to Portuguese. The questionnaire was pre-tested with three Brazilian postgraduate students in areas related to farming. The pre-testing was performed to check the adequacy of the terms used and the clearness of the questions. Only after those steps, did the questionnaire reached its definitive form.

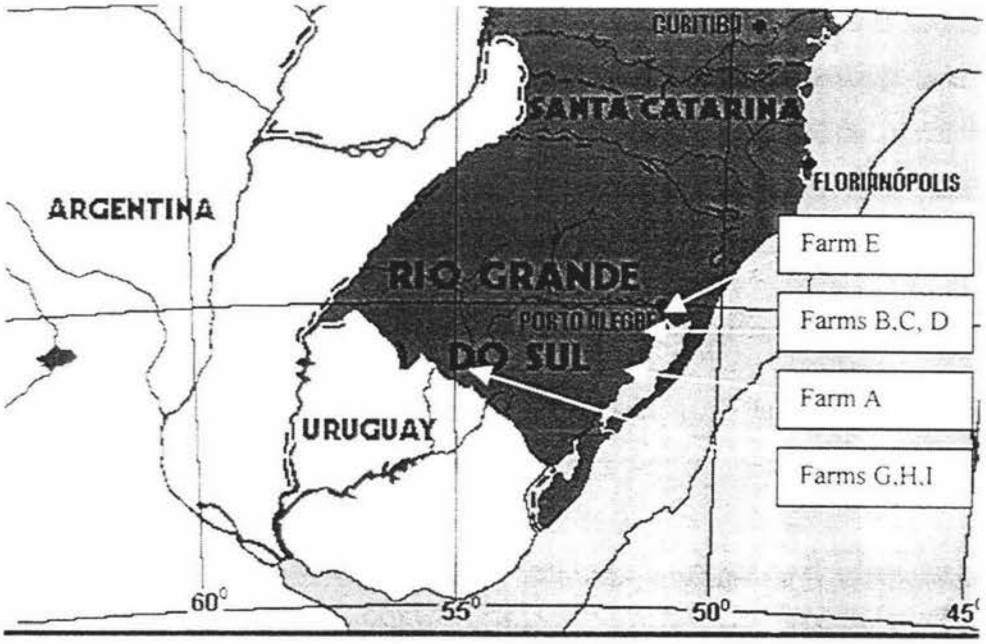
The structured questionnaire was used because of the difficulty created by the distance between the researcher and the interviewees. The use of matrices during the interview was because it reduces bias and allows focused answers. Since the research is a multiple-case study, the use of matrices would provide the possibility of comparison between cases.

4.2 Data collection

The sample of this research was not previously determined. Two "key informants" were used to select the interviewees. One of the two key informants, also one of the farmers interviewed, indicated the other farmers to be interviewed. The other key informant belongs to a rural syndicate and indicated other members to take part in the research. The only criterion for the selection was that the farmer should be in the beef production business. There was no restriction about farm size, age or stage of the farming business.

The questionnaires were sent by fax accompanied by a covering letter explaining the purpose of the research to a person in Brazil, in charge of the interviews. The interviewer was directed by the researcher as to the guidelines of the interview, and the objectives to be reached through telephone calls. The interviewer carried out the interviews during the months of November and December 1998. The questionnaires were sent back to the researcher by fax. Nine farmers were interviewed. Six of them are from the East region of Rio Grande do Sul (see Figure 4.1). The other three farmers are from the Southwest region of the state, near the border with Uruguay. Both are traditional beef production areas in the state.

Figure 4.1: Map of Rio Grande do Sul with location of farms



4.3 Data analysis

As described in sections 3.4 and 3.8, the methodology used in the data analysis was qualitative. It was considered that this approach would meet the objectives of the research because of the richness of information it can provide. Data from the questionnaires were already partially reduced due to the use of matrices during data collection. The remainder of the data were reduced to matrices once all the cases were put together (refer Chapter Five). Once the data were reduced, some connections were created in order to answer the questions implicit in the objectives of the research.

From "Questionnaire 1", data were used to build profiles of the farmers. The data: age, education, living in the farm, other activity besides farming, years farming, family background and goals and objectives were used to infer about the farmers' characteristics in relation to the farming business.

Farm data were connected between each other. Farm size was related to main activity, and the number of employees and area of pastures used as a percentage of the total area were used to conclude about resources used in the farm and degree of investment. Number of head, main activity and livestock data were used to draw conclusions about farm productivity. All the data were used to understand the farmers' circumstances. The farmers' circumstances and the farmers' profile were used to analyse the influence they have on the farmers' attitudes towards technologies.

To achieve the first objective: determine the attitude of farmers towards adoption and use of technologies, the analysis of the answers in question 1 in Questionnaire 2, that refer to the use of technologies was used. The analysis of question 4 and 5 could reveal the farmers' receptive attitudes towards new technologies. The analysis of farmers' goals and objectives could also indicate the degree of "entrepreneurism" of the farmers.

In order to answer the second objective: reasons for adoption/rejection and use of technologies, the two matrices (question 1 and 2) of Questionnaire 2 were used. From the answers in question 1, direct conclusions were drawn. The answers in question 2 were compared with Rogers' attributes of innovations, which was used as a framework. The analysis of farmers' judgements about the constructs related to each technology was compared with Rogers' framework with the objective of confirming or not Rogers' findings. Through this analysis it was possible to draw conclusions about whether or not the Rio Grande do Sul case follows the general assumption, or if there are different reasons for the adoption of technologies in beef production.

CHAPTER FIVE

5 Results and discussion

This chapter will show the results obtained in the interviews with the nine farmers in Rio Grande do Sul. In order to keep the confidentiality of the interviewees, the farmers will be referred to as Farmer A, B, C, D, E, F, G, H and I. Firstly, the results will be treated case by case, and next the cases will be compared.

5.1 Farmer's profile

The following section will present the results obtained in the first part of the interview, Questionnaire 1. The farmers were asked for some personal details as well as some farm data, in order to build a background profile for further comparisons and conclusions. The data are summarised in tables (Table 5.1 and Table 5.2) shown after the detailed report.

Farmer A

Farmer A is 36 years old. His father and grandfather were also farmers, and despite having a degree in Engineering, he has been in the farming business for ten years. He does not live on the farm, but does not have another activity generating income besides farming.

The farm is located in the East region of the state (refer Figure 4.1). The farm size is 1,448 ha, and there are 175 ha cultivated with pastures. The farm has four full-time employees. Nine hundred head of crossbreeds make up the herd. The main activity is breeding, with a stocking rate of 1.1 head per hectare, discounting areas not used for cattle breeding (agriculture and native forest). The mortality rate is 2 per cent and the calving rate is 70 per cent. Slaughtering age, and weight gain per hectare were not answered because they are not relevant to breeding activity. Farmer A's goals and objectives are, in the short term to increase gain per hectare/year, and in the long term to increase financial results.

Farmer B

Farmer B has been in the farming business for twelve years. He is 33 years old and has a degree in Veterinary Medicine. His father and grandfather were also in the farming business. He does not have any other income besides farming, and does not live on the farm.

The farm area is 436 ha and is located in the East region of Rio Grande do Sul. The area cultivated with pastures is 122 ha. There are four full-time employees, and the main activity is breeding and finishing cows for the domestic market. The herd is 450 head of crossbreeds. The stocking rate is one head per hectare, the mortality rate is 1.5 percent and calving rate is 60 percent. The slaughtering age is three years, and weight gain per hectare is 110 kg per year. The goals and objectives of Farmer B are, in the short and long term, to improve productivity and, consequently, to achieve better financial results.

Farmer C

Farmer C is 30 years old. He lives on the farm and has a degree in Business Management. His background in the farming business comes from his father and grandfather. He has been working on his father's farm as a parallel activity while completing his education, and he has been working as the farm manager for five years.

The farm area is 1,200 ha, from which 400 ha are used for forestry. The remaining 800 hectares are used for cattle breeding, the main activity, and cultivation. There are six full-time and two part-time employees. The farm has 500 ha cultivated with pastures of different types. The herd is 680 head. Livestock data are: a stocking rate of 0.85 head per hectare, a mortality rate of 1 per cent, and calving rate of 76 per cent. The slaughtering age, and weight gain per hectare were not answered because they are not relevant data for breeding activity. Farmer C has very specific goals and objectives. He intends, in the short term, to mate all heifers at fourteen months, and, in the long term, to double the stocking rate.

Farmer D

Farmer D has been in the farming business for fourteen years. He is 37 years old and has a degree in Media Studies. Because of his family background in the farming business (father and grandfather), and the opportunity to make a living as a farmer, he changed from his original profession. He lives on the farm and has international trade as a complementary activity to farming.

His farm is 670 ha and located in the East region of RS. There are two employees, one full-time and one part-time. The area of pastures is 180 ha, and the herd is 300 head of Hereford. The main activity is breeding, with the following livestock data: a stocking rate of 0.5 head per hectare, a zero mortality rate, a calving rate of 80 per cent, a slaughter age of 2.5 years, and weight gain per hectare of 216 kg per year. In the short term, Farmer D's goal is to increase the area of pastures. In the long term, the goals and objectives are to include finishing in the activities of the farm, and to increase the weight gain per hectare, aiming for the export market.

Farmer E

Farmer E is 39 years old and has been in the farming business for 21 years, following the profession of his father and grandfather. He did not complete his degree in Law. He does not live on the farm because he divides his time between the farm and his other businesses: a rice processing factory and a pasta factory.

The farm has 837 ha and is in the East region of RS, and stretches to a lagoon (Lagoa dos Patos). The pasture area is 225 hectares. There are five full-time employees, and one part-time worker. Eight hundred head constitute the herd of Devon, Hereford and Aberdeen crossed with Nelore. The main activity is finishing with the following livestock data: a stocking rate of 1.5 head per hectare, a mortality rate of 1 per cent, a slaughter age of 2.5 years, and weight gain per hectare of 250 kg per year. His goals and objectives in the short term are the increasing of pasture area and correction of the soil (pH and level of minerals). In the long term, he intends to explore 100 per cent of the farm area, with each area used for the aptitude of each type of soil. For instance, areas with more capacity for rice culture being cultivated; areas suitable for pastures being cultivated and having the soil corrected; and areas suitable for forestry being cultivated with eucalyptus or other species.

Farmer F

Farmer F lives on the farm, even though he has another activity besides farming: a car dealing enterprise. He has a degree in Business Management and Law. He is 44 years old and has been in the farming business for 20 years. The farming background comes from his father, grandfather, great-grandfather, showing a tradition in the family.

The farm area is 119 ha, having one part-time worker and three full-time employees. The area of pastures is 65 hectares, cultivated with oats. He has 800 head of crossbreeds for finishing. He uses the feedlot system, that explains the high number in the livestock data: a stocking rate of 6.72 head per hectare, a mortality rate of less than 0.2 per cent, and weight gain per hectare of 700 kg per year. His goal in the short term is to aggregate more value to the finished animals. In the long term, he wants to establish partnership with farmers in the breeding activity and slaughtering houses to improve remuneration and decrease investments.

Farmer G

Farmer G is 65 years old. He does not live on the farm, and does not have any family background in the farming activity. He has been in the business for fifteen years. He does not have a University degree.

His farm is located in the Southwest region of RS, and has 1,200 ha. There is one part-time, and three full-time employees. The area of pastures is 1,100 hectares of different types. The herd of 1.100 head is Aberdeen Angus. The farm activity includes the complete cycle: breeding, fattening and finishing, and includes the production of bulls. The livestock data are: a stocking rate of 0.8 head per hectare, a mortality rate of 2 percent, a calving rate of 75 percent, a slaughter age of 1.5 years, and weight gain per hectare of 120 kg per year. His goals in the short term are to increase the calving rate and to increase the stocking rate. In the long term, he aims to improve pasture utilisation through the rotation system.

Farmer H

Farmer H is 54 years old. He lives on the farm and has farm management as a complementary activity to cattle breeding. He has no University degree. His background in farming comes from his uncles and cousins. He has been in the business for 30 years.

His farm of 5,200 ha is located in the Southwest region of RS. There are eighteen full-time, and four part-time workers. The area cultivated with pastures is 1,070 ha. The herd consists of 4,000 head of Aberdeen Angus and crossed zebu breeds. The main activity includes breeding, fattening and finishing. The livestock data are: a stocking rate of 0.77 head per hectare, a mortality rate of 1.5 percent, a calving rate of 80 percent, a slaughter age of 2 years, and weight gain per hectare of 115 kg per year. His goals and objectives for the short and long term are to increase productivity and cost reduction.

Farmer I

Farmer I is the fifth generation of a family of farmers. He is 53 years old and has a degree in Law. He does not live on the farm, and works as a lawyer besides being in the farm business for nineteen years.

His 2,700 ha farm is located in the Southwest region of RS. On the farm there are 19 full-time employees. There are 10 people working part-time. The herd is of 2,500 head of Aberdeen Angus and crossbreeds. The main activity is breeding, fattening and finishing. Livestock data are as follows: a stocking rate of 0.9 head per hectare, a mortality rate of 1 percent, a calving rate from 70 to 75 percent, a slaughter age limit of 3 years, and weight gain of 125 kg per hectare per year. His goals and objectives are: in the short term, to increase the calving rate to 85 percent, and, in the long term, to improve finishing.

Table 5.1: Summary of farmer's personal data

Farmer	**Age**	**Education**	**Living in the farm**	**Activity besides farming**	**Years Farming**	**Family background in farming**
A	36	Engineering	No	None	10	Father and grandfather
B	33	Veterinary	No	None	12	Father and grandfather
C	30	Business Management	Yes	Agriculture and Forestry	5	Father and grandfather
D	37	Media Studies	Yes	International Trade	14	Father and grandfather
E	39	Law (incomplete)	No	Rice processing and Pasta Factory	21	Father and grandfather
F	44	Law and Business Management	Yes	Car dealing enterprise	20	Father and grandfather and grand-grandfather
G	54	Secondary School	No	Agriculture	15	None
H	53	Secondary School	Yes	Farm management	30	Uncle and cousins
I	65	Law	No	Lawyer	19	Fifth generation of farmers

Table 5.2: Summary of Farm data

Farm	Size (ha)	Region in RS state	Number of employees Full-time / Temporary	Pastures Area (ha)	Pastures (% total)	No. of head and breed	Main activity
A	1,448	South-east	4 / 0	175	12	900 / crossed breeds	Breeding
B	436	South-east	4 / 0	122	28	450 / crossed breeds	Breeding, Finishing
C	1,200	South-east	6 / 2	500	41	680 / crossed breeds	Breeding
D	670	South-east	1 / 1	180	27	300 / Hereford	Breeding
E	837	South-east	5 / 1	225	27	800 / crossed breeds	Fattening, Finishing
F	119	South-east	3 / 1	65	54	800 / crossed breeds	Finishing
G	1,200	South-west	3 / 1	1,100	91	1,100 / Aberdeen Angus	Breeding, Fattening and Finishing
H	5,200	South-west	18 / 4	1,070	20	4,000 / Aberdeen Angus and crossed	Breeding, Fattening and Finishing
I	2,700	South-west	19 / 10	570	21	2,500 / Aberdeen Angus and crossed	Breeding, Fattening and Finishing

Table 5.3: Summary of Livestock data

Farm	Stocking rate (head/ha)	Mortality rate (%)	Calving rate (%)	Slaughter Age (years)	Weight gain/ ha / year
A	1.1	2	70	-	-
B	1	1.5	60	3	110
C	0.85	1	76	-	-
D	0.5	0	80	2.5	216
E	1.5	1	-	2.5	250
F	6.72	0.2	-	-	700
G	0.8	2	75	1.5	120
H	0.77	1.5	80	2.5	115
I	0.9	1	70 to 75	3	125

Data from the first questionnaire showed that almost all the farmers interviewed, except one, have a family background in the farming business. Eighty percent of the farmers interviewed have been in the business for more than ten years. Most farmers do not live on the farm and maintain an activity besides beef cattle raising.

The farms with large areas tended to include in their activity the complete cycle of breeding, fattening and finishing, or are concentrated on breeding. The area of pastures does not follow a pattern. The number of employees is higher in the larger farms, that means higher fixed costs.

Despite the large areas of land, the livestock data of larger farms do not have the highest rates. The smallest farm, because of the use of the feedlot system, has the highest weight gain/ha/year.

5.2 Farmer's perceptions and use of the five selected technologies

Questionnaire 2 had the objective of investigating the use of the five selected technologies, and determining farmers' attitudes towards adoption and use of technologies. The following section will present a description of the results obtained in questions 1 and 2, followed by a summary of the results in tables.

Technology: Artificial Insemination

Published information (FNP 1996) makes clear the benefits of using artificial insemination in cattle breeding activity. One of the main advantages is the access to superior genetics, without the need for investing in pure-bred bulls. However, some aspects must be taken into consideration when considering the efficiency of the practice. The formula to achieve good results, according to a farm consultant, is to have a number of heifers in oestrus, fertile animals, a good inseminator, and semen of very good quality. The fulfilment of those requirements is imperative to the success of the technique.

Most of the farmers use artificial insemination on their farms. Two of them do not use the technology because it is not compatible with the main activity of their farms, which is fattening and finishing. One of the farmers used the technology for one year, but does not use it currently. The reason is that "it requires time and specialised people". He considers the cost and financial benefit of the technology very advantageous, despite the time and labour required, and herd management as constraints for its use. Farms with larger labour resources tend to make greater use of artificial insemination, having been using it for a longer period. The other farmers that currently use the technology consider it strongly advantageous, even in relation to the constraints mentioned before. It demonstrates that time and labour demand is not necessarily a reason for not using the technology, but it influences the decision of use.

The general perception of the technology is associated with cost and financial benefit as positive factors, while time and labour demanded and herd management are associated as negative factors. Two of the farmers considered the complexity/flexibility of the technology as a disadvantage and strong disadvantage. In general, the farmers agreed that no risk is involved in the use of artificial insemination, and considered it a flexible and accessible practice. All farmers who have breeding as the main activity in their farms consider the technology highly compatible with their objectives, and visibility of results was considered one important factor, taking into consideration its positive rating. The same farmers classified artificial insemination as one of the most relevant technologies used in their farms.

Technology: Utilisation of Salt/Urea

The utilisation of Salt/Urea during the off-season of pastures or drought seasons has been an alternative nutritional supplement for cattle. By replacing the lack of protein and minerals in pastures during those seasons, it helps to maintain the level of productivity of the herd, as measured by weight gain and fertility.

Salt/Urea is not widely used amongst the case study farmers. Three of them do not use any nutritional supplement because they consider the cost very high, despite the fact that they recognise the financial benefits of its use. One of the farmers said that he does not use it because he did not have information about it. However, he has used Salt without Urea for more than twenty years. Another farmer does not use the nutritional supplement given the large area of pasture on his farm. He plans to use them, so he will not need to use any other nutritional supplementation. One of the farmers uses it only during winter to supply feed shortages during the season, but uses Salt during the periods.

The relationship between the use of Salt /Urea and the constructs classified in the matrix is the following: farmers that do not use it consider the high cost as the major constraint, while the ones who use it think it is an advantage, or consider cost as a neutral factor. Risk is perceived as neutral or a positive factor, as well as herd management and complexity/flexibility of use. The financial benefit was perceived as the weight maintenance of the herd during the off-season period. The visibility of results was classified as a neutral factor, and in two of the cases, was classified as an advantage and strong advantage. The compatibility with objectives varies from strongly negative to strongly positive, depending on the objectives of the farmer. Farmers concerned with cost reduction classified it as a strong disadvantage, while farmers concerned with herd improvement considered it a strong advantage. However, the technology was rated as one of the less important used in the farms.

Technology: Utilisation of Fertilisers and Soil correction

Besides the favourable effect on the soils and in many crops, the use of fertilisers or supplements for soil correction has many benefits for pastures, and, consequently, for the cattle. Cattle fed in areas adequately fertilised and with the soil corrected will probably follow a better pattern of productivity.

The utilisation of fertilisers and soil correction is a widely used technology by all the case study farmers. It is a consensus among farmers that it is fundamental for cattle raising activity, and it is considered indispensable for the improvement of pastures and soil. The association of that technology with high costs is compensated by its associated financial benefits. Some of the farmers considered time and labour demand as high, while fifty percent of them considered it as an advantage, as well as herd management. Complexity and flexibility of the technology were considered, by almost all farmers, as an advantage. The case study farmers agreed that the visibility of results is an important factor. They also considered the practice as highly compatible with their objectives. The utilisation of fertilisers and soil correction was among the most relevant technology used in the farms according to the technology ranking.

Technology: Parasite and Disease Control

Parasites, as known, decrease the productivity of the herd. On the farm, this effect can be perceived by lower rates of gain showed by the animals with parasites. Besides that, parasites increase mortality rates. In the slaughtering houses, the effect of parasites becomes evident with the lower quality of carcasses and devaluation of the skin. This shows the importance of parasite and disease control in all stages of production for the minimisation of those effects.

Parasite and disease control was ranked as the number one technology in importance of use in the farms. All the farmers use it to: decrease mortality rates, improve the health and performance of the herd, and increase productivity. The classification of this technology in relation to cost was positive, and its financial benefit was considered an extremely important consideration in its use. Most farmers seemed to have no doubt about the positive effect of the technology used, rating it as a strong advantage. Time and labour required was rated in a range from disadvantageous to strongly advantageous. Herd management was, in general, considered a strong advantage, except by two farmers who considered it a strong disadvantage. Complexity and flexibility of use was classified from neutral to strong advantage. The visibility of results was perceived as a highly positive factor associated with the technology. All farmers considered parasite and disease control compatible with their objectives.

Technology: Soil Testing

Soil testing provides information to help guide farmers towards achieving an appropriate level of pasture growth through improved soil fertility. It is assumed that all farmers that make use of fertilisers and soil correction technology should use soil testing as a procedural tool. Soil testing is considered a decision support tool, having fertiliser application as an outcome of the information used.

Despite not being considered one of the most important practices on the farms, soil testing is used by all case study farmers. It is considered a valuable tool for the correct use of fertilisers and nutrients for the soil. One of the farmers mentioned soil testing as a tool to follow the improvement of the soil, and he uses it always when implementing a new pasture. The cost of soil testing is one of its main advantages, associated with its positively rated financial benefit and no risk. Little time and labour is required for soil testing, and it is reflected in the factor rating from strong advantage to neutral. The same rating was verified for the factor herd management and complexity/flexibility of use. Soil testing does not require any herd movement or treatment, and it is very flexible and easy to use. The technology does not show clear visibility of results if considered directly. Its results can be perceived only through the association of use with another technology. In relation to this factor, soil testing was rated from disadvantage to strong advantage. The technology also had a range of classifications from disadvantage to strong advantage concerning the compatibility with farmers' objectives.

Table 5.4: Farmers' perceptions of Artificial Insemination through constructs classification

Scale 5 to 1 (5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage)

Ranking 1 to 5 (1=most important, 5=less important)

Construct / Farmer	Cost	Financial benefit	Risk	Time and Labour	Herd Management	Complexity / Flexibility	Compatible with objectives	Visibility of results	Technology ranking
A	**3**	**3**	**3**	**1**	**1**	**1**	**5**	**4**	**2**
B	**4**	**4**	**3**	**2**	**1**	**4**	**5**	**3**	**2**
C	**4**	**5**	**3**	**2**	**4**	**2**	**5**	**4**	**3**
D	**5**	**5**	**3**	**1**	**1**	**3**	**3**	**4**	**4**
E	**4**	**5**	**3**	**2**	**2**	**4**	**3**	**4**	**5**
F	**4**	**5**	**3**	**2**	**1**	**3**	**3**	**5**	**5**
G	**5**	**5**	**4**	**3**	**5**	**4**	**4**	**5**	**2**
H	**4**	**5**	**2**	**4**	**5**	**5**	**5**	**4**	**2**
I	**5**	**5**	**4**	**4**	**4**	**5**	**5**	**5**	**1**

Table 5.5: Farmers' perceptions of utilisation of Salt/Urea through constructs classification

Scale 5 to 1 (5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage)

Ranking 1 to 5 (1=most important, 5=less important)

Construct / Farmer	Cost	Financial benefit	Risk	Time and Labour	Herd Management	Complexity / Flexibility	Compatible with objectives	Visibility of results	Technology ranking
A	**2**	**4**	**3**	**2**	**3**	**5**	**1**	**4**	**5**
B	**2**	**5**	**3**	**3**	**3**	**4**	**1**	**3**	**5**
C	**2**	**4**	**3**	**4**	**4**	**4**	**4**	**3**	**5**
D	**5**	**5**	**3**	**1**	**3**	**3**	**3**	**3**	**5**
E	**5**	**4**	**3**	**1**	**3**	**3**	**4**	**3**	**3**
F	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**
G	**4**	**5**	**3**	**3**	**3**	**5**	**3**	**3**	**5**
H	**3**	**3**	**2**	**4**	**5**	**5**	**5**	**3**	**2**
I	**3**	**3**	**4**	**3**	**4**	**4**	**4**	**3**	**3**

Table 5.6: Farmers' perceptions of utilisation of Fertilisers and Soil Correction through constructs classification

Scale 5 to 1 (5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage)

Ranking 1 to 5 (1=most important, 5=less important)

Construct / Farmer	Cost	Financial benefit	Risk	Time and Labour	Herd Management	Complexity / Flexibility	Compatible with objectives	Visibility of results	Technology ranking
A	**2**	**4**	**3**	**2**	**2**	**1**	**4**	**5**	**1**
B	**1**	**4**	**2**	**2**	**3**	**3**	**5**	**5**	**3**
C	**2**	**5**	**3**	**2**	**5**	**5**	**5**	**4**	**2**
D	**2**	**5**	**4**	**2**	**3**	**5**	**5**	**5**	**1**
E	**4**	**5**	**4**	**4**	**4**	**5**	**5**	**5**	**2**
F	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**
G	**3**	**4**	**3**	**3**	**3**	**4**	**4**	**5**	**3**
H	**3**	**4**	**2**	**4**	**5**	**5**	**5**	**4**	**1**
I	**4**	**4**	**4**	**4**	**3**	**3**	**4**	**4**	**2**

Table 5.7: Farmers' perceptions of Parasites and Disease Control through constructs classification

Scale 5 to 1 (5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage)

Ranking 1 to 5 (1=most important, 5=less important)

Construct / Farmer	Cost	Financial benefit	Risk	Time and Labour	Herd Management	Complexity / Flexibility	Compatible with objectives	Visibility of results	Technology ranking
A	**4**	**3**	**4**	**2**	**1**	**4**	**4**	**3**	**3**
B	**3**	**4**	**4**	**2**	**1**	**3**	**5**	**4**	**1**
C	**2**	**5**	**4**	**2**	**5**	**5**	**5**	**5**	**1**
D	**3**	**5**	**3**	**3**	**3**	**3**	**3**	**3**	**1**
E	**4**	**5**	**4**	**4**	**4**	**3**	**5**	**4**	**1**
F	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**
G	**4**	**5**	**3**	**3**	**5**	**4**	**4**	**5**	**1**
H	**4**	**5**	**2**	**4**	**5**	**5**	**5**	**5**	**1**
I	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**

Table 5.8: Farmers' perceptions of Soil Testing through constructs classification

Scale 5 to 1 (5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage)

Ranking 1 to 5 (1=most important, 5=less important)

Construct / Farmer	Cost	Financial benefit	Risk	Time and Labour	Herd Management	Complexity / Flexibility	Compatible with objectives	Visibility of results	Technology ranking
A	**5**	**2**	**5**	**5**	**5**	**5**	**2**	**2**	**4**
B	**5**	**3**	**5**	**5**	**5**	**5**	**3**	**2**	**4**
C	**3**	**4**	**3**	**2**	**3**	**4**	**5**	**5**	**4**
D	**5**	**5**	**3**	**3**	**3**	**3**	**3**	**3**	**1**
E	**5**	**4**	**3**	**3**	**3**	**3**	**5**	**3**	**4**
F	**5**	**5**	**5**	**4**	**4**	**3**	**5**	**3**	**3**
G	**3**	**5**	**3**	**3**	**4**	**4**	**4**	**5**	**2**
H	**3**	**4**	**2**	**3**	**4**	**4**	**5**	**3**	**2**
I	**5**	**5**	**5**	**5**	**3**	**3**	**5**	**4**	**5**

5.3 Farmers' attitudes towards the adoption and use of technologies

This section presents the results obtained in questions 1, 4 and 5 of Questionnaire 2, and the data are summarised in a table along with farmers' objectives to allow better visualisation and connections.

The case study farmers, in general, use all the five selected technologies, except utilisation of salt/urea, or artificial insemination in some of the studied cases. The farmers showed interest in a number of technologies related to beef production. Some of them are related to breeding activity, but there are others related to farm management, and even elimination of rubbish in rural establishments. The technologies mentioned are: crossbreeding, early weaning, electric fences, synchronisation of oestrus, irrigation and drainage, disease control, feedlot, grazing management, and silage.

Some of the farms have general goals and objectives like increasing productivity, reducing costs, increasing financial results, or increasing herd. Others have very specific objectives. Some of them refer to herd management: mate all heifers at fourteen months, aggregate value to finished animals, increase weight gain per hectare, improve finishing and increase calving rate. Others refer to farm management: increase area of pastures, correct soil, improve use of pastures, expand finishing activity, establish partnership with other producers and slaughter houses, and implant system to explore 100 percent of the farm area.

None of the case study farmers mentioned not having interest in any technology, and they commented that any technology related to beef production and to improve productivity rates and cost reduction is welcome. Two of the farmers expressed interest in the results of this study, and one of them asked information about some technologies.

Table 5.9: Farmers' use of technologies, goals and objectives and interest in other technologies

Farmer	Use of technologies	Goals and objectives	Interest in other technologies
A	Four of the technologies; no utilisation of salt/urea (thinks it is not necessary)	Increase gain/ha/year Increase financial results	Cross breeding and early weaning
B	Four of the technologies, no utilisation of salt/urea (cost)	Improve productivity Improve financial results	Cross breeding and early weaning
C	All five technologies	Mate all the heifers at 14 months Double stocking rate	Electric fences, synchronisation of oestrus
D	Three of the technologies; no utilisation of salt/urea (thinks it's not necessary), no artificial insemination (high time and labour demand)	Increase areas of pastures, expand finishing activity, and increase gain of weight/ha.	Elimination of rubbish in rural establishments
E	Four of the technologies, no artificial insemination (not compatible with activity)	Increase area of pastures, correct soil and implanting system to explore 100% of area.	Water use: irrigation and drainage, disease control, and elimination of rubbish.
F	Four of the technologies, no artificial insemination (not compatible with activity)	Aggregate value to finished animals Establish partnership	Feedlot
G	Four of the technologies, no utilisation of salt/urea (large area of pastures)	Increase calving rate, stocking rate Improve use of pastures	Grazing management, silage and cross breeding
H	Four of the technologies, no utilisation of salt/urea (lack of orientation)	Increase productivity and reduce costs	Any technology associated to cost reduction
I	All five technologies	Increase calving rate to 85%, and improve finishing	Feedlot and any technology to improve productivity rates

5.4 Discussion

The results from the previous sections will be discussed following the guidelines mentioned in Chapter Four, section 4.3, in order to answer the two main objectives of this study. In the literature review, no studies about farmers' attitudes towards adoption and use of technologies were found. Studies related to adoption and use of technologies in farming systems in developing countries referring, in general, to the constraints or factors affecting the rate of technology adoption. For this reason, it was not possible to make comparisons with previous research on farmers' attitudes towards technologies in Brazil or even in South America.

Looking at the farmers' profiles, no relationship between the decision of adopting and using technology, and age were found. The range of farmers' ages varied from 30 to 65, and the cases studied did not show a pattern of behaviour according to age and the adoption and use of technologies. The same situation is applicable to family background in farming, years farming and education. Eight out of the nine farmers interviewed have a family background in farming. However, they do not show an attitude towards technologies different from the farmer that does not have a family background. Years farming varied from 5 to 30 years. As well as farmers' age, it is was not possible to verify a pattern of attitude among those who have more years of experience, or the ones who have less years in the business.

It was verified that, despite the fact that some of the farmers have university degrees in areas related to agriculture or management, this was not an influence on the decision of adopting and using technologies. Farmers that did not have degrees or education related to farming did not show less predisposition in adopting or using technologies in their farms.

Most of the farmers' professional activities besides farming are related directly or indirectly with farming, and most of the farmers do not live on the farms, but in cities close to the farms. It is possible to associate these factors to: exposure to information, and external off-farm income analysed in previous researches (Feder et al. 1981). However, neither of these factors seems to have a significant effect on the decision process.

Through the observation of farm data, it was verified that some factors influence the adoption behaviour. Farmers whose farm's main activity is breeding are interested in the use of technologies directed to genetics, like crossbreeding, and artificial insemination. Farmers in the activities of fattening and finishing are interested in technologies related to grazing management and general farm management. Farms with more labour availability are more likely to use technologies perceived as labour demanding, like artificial insemination. Farm size did not show a direct influence on the use of the technologies, but it is possible to affirm that farm size has an indirect effect on the use of technologies. For this finding, it is necessary to consider that farm size is closely related to farm activities (larger farms tend to perform more activities, while smaller farms are more likely to be concentrated on one main activity), and that farm main activity determines the adoption behaviour.

From the cases studied, one farm showed a high rate of weight gain per hectare, determined by the use of a technology other than the five selected: feedlot. Another farm showed high productivity rates by the use of pastures in large scale, that means the use of another technology: grazing management. The five selected technologies are basic technologies commonly used in beef production. It was confirmed, through those cases, that the use of other technologies has a direct and evident effect on the rates of productivity.

For the discussion about the factors affecting the adoption and use of technologies, the analysis of the relationship of farmers' perceptions of the five technologies, and the attributes to innovation assigned by Rogers (1983) in Chapter Three, section 3.2 were used. Although not definitive to the adoption decision, the attributes proved significant to the behaviour. The attributes were analysed one by one relating to farmers' perceptions of the technologies crossed with the constructs created to represent in meaning each one of the attributes.

Relative advantage

Relative advantage, as defined by Rogers (1983) is the degree to which an innovation is perceived as being better than the idea it supersedes, and was measured by the constructs cost, financial benefit, time and labour required and herd management.

In the five technologies, the factor financial benefit was classified as advantage or strong advantage. The factor was considered a strong determinant of adoption and use of the technologies. Factor cost had a different classification. In one case, cost was classified as a disadvantage, and was decisive to the decision of not using salt/urea. In the situation of the other technologies, when classified as a disadvantage, the factor was surpassed by the positive classification of other constructs like financial benefit. The comment of one of the farmers: "expensive is the pasture that do not produce" concerning the use of fertilisers and soil correction, can illustrate the finding. Even when some of the technologies were perceived as costly, the farmers used them because of other benefits.

Time and labour demand was decisive for the use of artificial insemination in one of the cases studied. This factor was classified as a disadvantage, mainly in the technologies: parasite and disease control and use of fertilisers and soil correction. In the other cases studied, and in relation to other technologies, when the construct was classified negatively, this negative perception was compensated by the financial benefits that the technology can produce. The factor herd management was classified as a disadvantage only in relation to technologies demanding it: parasite and disease control and artificial insemination, but it was not a factor determining the adoption decision.

By the analysis of the four constructs related to the attribute "relative advantage", it was found that financial benefit plays a major role in the decision process. The other factors associated with the attribute are important to the decision behaviour, but they are usually weighed up against its financial benefit.

Trialability

The degree to which a technology can be used on a small scale (Rogers 1983), is intimately related to the degree of risk it can represent. The possibility of trial decreases its uncertainty. The construct used to measure this attribute was risk.

The perception of risk in relation to the five technologies was usually neutral or positive. In none of the cases, was it mentioned as a factor affecting farmers' decisions. Although risk involves financial investment, considered important by the farmers, the fact that the five technologies and their results are widely known, may have influenced farmers' positive perceptions of risk. It is not possible to draw conclusions about the influence of this attribute in the farmers' decisions, because it was not mentioned as a relevant aspect.

Complexity

The complexity of a technology refers to the degree of perceived difficulty in understanding and using it (Rogers 1983). In relation to the five selected technologies, artificial insemination was mentioned as requiring specialised people, or perceived negatively in relation to complexity. Although the technology demands a number of ideal conditions to follow, its complexity was not a determining factor in the adoption decision.

None of the farmers suggested that any of the other selected technologies were difficult to understand, use or adapt. However, one of the farmers recognised that he did not use salt/urea due to lack of information. In this case, complexity could be considered as a decisive factor in the adoption decision.

Years farming is probably responsible for the farmers' opinion. Previous experience with the technologies decreases the perception of complexity, and all the farmers have been in the business for more than five years. Complexity could not be evaluated isolated from farmers' circumstances, because it was strongly related to their knowledge and farming experience. From the discussion above, it is possible to say that complexity may be an attribute affecting the decision of the farmers, but given the low occurrence of cases referring to it, it can not be affirmed positively.

Observability

Defined as the degree of which an innovation's results are visible to others (Rogers 1983), observability of the selected technologies can be measured more clearly by its hardware aspect. Except soil testing, the results of which are not observable unless combined with the use of fertilisers or soil correction, the other four technologies have a clear observable aspect. Soil testing, in the case study, was the only technology classified negatively by two of the farmers, but had three positive classifications because it was immediately linked to the use of fertilisers and soil correction.

The perception of the visibility of the results of the other technologies was considered neutral or positive, and none of the farmers mentioned difficulties in observing the results obtained from the use of the technologies. Definitely, the attribute observability was not a decisive factor in the adoption decision.

Compatibility

The degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters (Rogers 1983) showed to be an important factor affecting the decision of the use of technologies. Farmers were very positive when talking about the use of technologies in relation to their objectives and interests.

Farmers with specific objectives had the use of technologies strongly linked with their goals. The perception of compatibility in relation to unused technologies, from the selected ones, was neutral or negative, while the perception of the used technologies was usually classified positively. The use of different technologies was also mentioned when speaking about farmers' projects on the farms.

Past experience with the technologies also showed a degree of significance, as well as farm resources. In one case, the farmer considered the use of artificial insemination as irrelevant because he used it before and considered that its results did not justify the continuance of the use. In two other cases the farmers considered it unnecessary to use salt/urea because of the resources (soil condition and pastures) on their farms.

The analysis of Rogers' attributes of innovations and the results obtained from farmers' perceptions of technologies lead to the conclusion that Rogers' five attributes of technologies affect the studied farmers' decision of adoption and use of technologies. However, the attributes have different degrees of influence in the decision. Decisions regarding all the five technologies were mainly based on farmers' perceptions of relative advantage and compatibility with their objectives. The attribute complexibility showed some degree of influence, even though it could not be considered a decisive factor. In relation to the remaining attributes trialability and observability no positive conclusions could be drawn. Although the perceptions of risk and observation of results showed not to be definitive factors to the adoption decision, farmers' comments about those factors were not detailed enough to allow more definitive conclusions.

Farmers' perceptions of technologies demonstrated that the reasons for adoption/non adoption of a technology are more related to other factors than to the intrinsic characteristics of the technology itself. The effects that the technology can have, or the benefits it can bring, have more impact in the adoption decision than its perceived body of knowledge. The cost, financial benefit, farm resources and farmers' objectives were shown to have a high degree of influence on their choice. The complexity of use and understanding, and the flexibility of the technology to be adapted, were not reasons strong enough to influence its use or not.

The research findings showed that the case study farmers are very receptive towards the introduction of technologies. More than that, farmers showed a very enthusiastic attitude in relation to new technologies. However, the emphasis on financial benefit that farmers showed, suggests that they are constrained by financial factors. That finding supports the background given in Chapter One and Two, that explains the crisis of the agricultural sector in Brazil and the poor performance of Brazilian beef cattle production.

Contrary to the assertion by Ayre-Smith (1976) that one of the problems encountered when attempting to introduce innovations in developing countries is lack of entrepreneurs, the case study farmers showed a significant degree of entrepreneurism. This was verified through the analysis of farmers' objectives which include the adoption of technologies in their improvement plans. None of the farmers commented about the intention of expanding the area of the farms. The common idea was the intensive exploration of their farms in order to achieve higher rates of productivity.

Of the five technologies used in this study, the use of salt/urea can be considered the newest technology, replacing the use of mineral salt only. This technology showed to be the least used among the farmers interviewed. Although farmers' showed strong interest in technologies, it was verified low rate of use of new technologies. The positive attitude towards the adoption of innovations is inconsistent with their behaviour in this case. This fact can be explained by the existence of constraints other than farmers' willingness to change. Their comments about cost reduction and increments of productivity suggest the need to improve efficiency in their businesses. However, it is beyond the scope of this research to analyse the financial efficiency of the farms, and the measures to be taken in order to improve efficiency.

5.5 Limitations of the research

The main limitation of the research was the distance between the researcher and the interviewees. Budget and time were major constraints to the realisation of the interviews by the researcher. The structured questionnaire used, although in this multiple-case study it did allow many comments, restricted the richness of details so important in a qualitative research.

Another limitation was the fact that case studies cannot make generalisations to populations. Despite the number of cases studied, conclusions about the whole country situation can not be reached. However, this study can be used as a first step towards a deeper and more comprehensive research on the topic studied. The importance of the beef sector to the Brazilian economy, and the importance of the role of extension services to increase the rate of technology adoption are facts that justify the realisation of further researches in the area.

CHAPTER SIX

6 Conclusions

This study has investigated farmers' attitudes towards adoption and use of technologies in beef production in the South of Brazil, and the reasons for the use/ non-use of them. The approach used was qualitative, with a multiple-case study, and nine farmers in the region were interviewed. The principles of Farming Systems Research were followed when considering the fundamental influence of the farmer in the farming system. For the data analysis, matrices and Rogers' attributes of innovations were used as a framework.

Rogers suggests that the rate of adoption of an innovation is determined by its attributes: relative advantage, compatibility, trialability, complexity and observability. The attributes are perceived differently by potential adopters, and the perceptions can help to predict the adoption behaviour. The investigation consisted, fundamentally, in questioning the farmers in relation to five selected technologies: artificial insemination, utilisation of salt/urea, use of fertilisers and soil correction, parasite and disease control, and soil testing. The farmers were asked about personal data and farm resources, as well as their goals and objectives and interest in other technologies.

The analysis consisted of comparing farmers' perceptions of the technologies with Rogers' attributes, and analysing their attitudes towards the adoption and use of innovation through the analysis of its profile, objectives and interests. Matrices with simplified data were created in order to organise and connect the data.

The comparison of Rogers' attributes with the results obtained about farmers' perceptions of the five technologies suggests that those attributes exert influence on the decision process. Some of the attributes are decisive for the adoption decision, while others are not so important for the decision process when there are other factors involved. The case study farmers made it clear that financial benefit is one of the main attributes when considering the adoption and use of a technology. Other attributes like cost, time and labour demanded, and herd management are strongly considered but are not decisive. Risk and observation of results are considered but are not of major significance. Complexity and flexibility of a technology are important attributes contributing to the adoption decision, although they do not determine it. Finally, compatibility with farmers' objectives was found to be a primary determinant of technology adoption.

The analysis of the farmers' profiles, objectives and interests demonstrated a very favourable attitude towards the adoption of technologies. Despite the farmers' intentions to improve their farms, their ability to react to economic changes, and the fact that they have remained in the farming business over the years, the results suggest that they are limited by financial constraints. When formulating and recommending the adoption of new technologies, researchers and extension services should concentrate on the expected financial benefits of agricultural technologies use, and the choice of technologies consistent with farmers' financial and environmental circumstances.

Farmers' willingness to change, by the utilisation of technologies to improve their farms performance and the intensive exploration of their land, demonstrates that the extensive production model, characteristic of Brazilian beef farms, is changing to intensive production. The positive farmer attitude towards adoption and use of technologies is one aspect of that change.

This study, although with limitations, was the first step in understanding the adoption and use of technologies in beef production, from the perspective of Brazilian farmers. The report and results obtained support that further research in the area would be beneficial to the beef sector, in order to increase the rate of technology adoption. It is suggested that a survey in a larger area of coverage and with a larger number of farmers be conducted to validate the results of the present research. It is also suggested that researches involving agricultural researchers, extension agents, and farmers concerning improvements in beef production by the adoption of new technologies be conducted. The knowledge of farmers' needs and objectives is a way to achieve successful results in the innovation-decision process when developing and recommending adequate technologies.

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Appendix

Cover letter, Questionnaire 1 and Questionnaire 2

Dear farmer,

We want to contribute to the improvement of the Brazilian beef sector. The development and use of adequate technologies in beef production can increase productivity and improve your farm performance. We consider that the knowledge of Brazilian farmers' circumstances, and their attitude towards technology adoption and use in beef production, is an important part of the process. This questionnaire is part of a research conducted at Massey University, New Zealand, and your answers will help us to achieve our objective.

The research will take place in Rio Grande do Sul because it is a traditional and important state in this activity. The complete "interview" will include two different questionnaires. The first is about your personal data and farm resources. The second is about your perceptions of selected technologies in beef production. The answers will require some of your time, but it is essential that you give complete and descriptive answers in order to allow the achievement of deep knowledge of your environment and management system.

All responses will be treated with absolute confidentiality and will be used for the purpose of this study only. You can return the questionnaires by fax to Carlos Eduardo Borba Nunes through a collect call to the telephone number (051) 3429175, or by e-mail to the address duque@xtra.co.nz. Thank you for your valuable contribution to this research. We very much appreciate your assistance.

Sincerely,

Fernanda Borba Nunes
Postgraduate Student

Dr. William C. Bailey
Professor of Agribusiness

Questionnaire 1

Personal data

1. Name:

2. Age:

3. Address:

4. Phone/Fax: E-mail address:

5. Do you live in the farm? Do you have any other activity besides farming?

6. Education:

7. Do you have any family background in the farming business?

8. Years farming:

Farm data

9. Size:

10. Region:

11. Number of employees: - Full-time: - Part-time:

12. Pastures:

Type		Area (ha)
White Clover	(Trifolium repens)	--------
Red Clover		--------
Brachiaria		--------
Azevem	(Lolium multiflorum)	--------
Other (please specify)		--------

13. Number of head: Breed:

14. Main activity:

	Breeding	Fattening	Finishing
(%)	--------	--------	---------

15. Livestock data:

- stocking rate:
- mortality rate:
- calving rate:
- slaughtering age:
- gain of weight per hectare (kg/year or months):

16. What are your goals and objectives with your farming business?

In the short term:

In the long term:

Questionnaire 2

1. Select the alternative that best describe your situation in relation to the technologies listed below, and explain your reasons:

Technology	Currently use. How long and why?	Have used but do not use currently. How Long and why?	Never used. Why?	Rejected at first but now use it. How long and why?
1.Artificial Insemination				
2.Salt/Urea				
3.Fertilisers / soil correction				
4.Parasites / disease control				
5.Soil testing				

2. What do you think are the advantages / disadvantages of using each technology in relation to the factors below ?

Use the following scale: 5=strong advantage, 4=advantage, 3=neutral, 2=disadvantage, 1=strong disadvantage

Rank the five technologies according to the relevance of use in your farm (1 =most important, 5= least important)***

Technology	Cost	Financial benefit	Risk	Time and Labour	Herd Manage-ment	Complexity / Flexibility	Compatible with your objectives	Visibility of results	Other (please specify)	*** Ranking
1.Artificial Insemination										
2.Salt/Urea										
3.Fertilisers / soil correction										
4.Parasites / disease control										
5.Soil testing										

Comments:

____

____

3. In what technology not listed are you interested? Why ?

4. In what technology not listed are you not interested? Why ?

5. Additional comments :

Thank you !