Understanding technology adoption and non-adoption: a case study of innovative beef farmers from *Mato Grosso do Sul* State, Brazil

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This study draws on social-psychology in an attempt to identify the various motivations for technology adoption (TA), including both economic and non-economic, and to gain insights into how and why Brazilian innovative beef farmers make decisions about whether or not to adopt particular technologies. Three major research questions are addressed: (1) is there diversity of major goals and values amongst Brazilian innovative beef farmers, and if so, how can this diversity be characterised?; (2) how does diversity within innovative beef farmers' goals and values affect adoption and non-adoption of technologies?; and (3) do innovative beef farmers use a different set of constructs when assessing different types of technologies? If so, why? Innovative farmers were targeted given their openness to new ideas, including innovations, and their social role in importing innovations from institutions onto farms.

Innovative farmers from *Mato Grosso do Sul* State (MS), Brazil, were purposively selected based on their self-enrolment in the Good Agricultural Practices Programme (BrazilianGAP) or in the Association of Producers of Young Steers (APYS), which are initiatives that promote good farming practices among beef farmers. The 15 farmers enrolled in BrazilianGAP who ran commercial family farms in MS were selected and six who agreed were interviewed. From APYS's 120 members, 30 cases were selected through a stratified random sampling based on herd size (small, medium and large). Some 21APYS' members were interviewed, resulting in 20 valid interviews. Using a constructivist-interpretivist philosophy and a case study strategy, investigations of 26 farmers about their goals, farming systems, and the rationale as to why specific technologies were or were not applied, were undertaken through semi-structured in-depth interviews, which were conducted on their farms. This study employed Ethnographic Decision Tree Modelling, Q-Methodology and Personal Construct Theory, and elements of Soft Systems Thinking and Grounded Theory.

Four main sets of goals and values were identified amongst the farmers through the sorting of 49 statements (Q-methodology), and were labelled the Professional Farmer (PF), the Committed Environmentalist (CE), the Profit Maximiser (PM) and the Aspirant Top Farmer (ATF). The PF aimed at running the farm in a professional way, based on sound technical and managerial practices. The CE put emphasis on the long-term sustainability of his farming system. The PM focused on technical issues to pursue his economic and lifestyle objectives. The ATF was seeking excellence and sought recognition for this.

Analyses of the aggregate adoption rates of these farmer types showed that, on average, they adopted 27 (60%) of the 45 technologies analysed, with production and managerial technologies having higher levels of adoption relative to environmental technologies. The levels of technology adoption found in this study were considerably higher than those of average Brazilian farmers, as the Brazilian Agricultural Census show. This confirmed the innovative character of the interviewed farmers and validated the sampling strategy to identify such farmers.

Although no relationship between the farmer types and the use of individual technologies can be claimed, results suggested that the farmers' goals (i.e., represented by the farmer types) tended to generally orientate technology adoption. Farmer types who were production-oriented (PF, PM and ATF) adopted more production technologies than the environmentally-driven type (CE). This CE type, in turn, had the highest adoption rates of environmental technologies of all farmer types. Although important for adoption behaviour, the farmers' goals were insufficient by themselves to determine their technology adoption behaviours, with multiple influencing additional factors identified.

Among these factors were the five technology attributes proposed by Rogers's (2003) adoption of innovations theory: compatibility, complexity, relative advantages, observability and trialability. Compatibility and the relative advantages of technologies were the most important attributes while observability and trialability were relevant, but of secondary importance. Complexity seemed to be considered alongside other aspects of technologies (e.g., cash returns) that define their relative advantages, rather than an attribute in itself. This study, therefore, expands Rogers' (ibid) propositions by identifying a hierarchy among the technology attributes.

Ethnographic decision tree models on a dry season supplementation for rearing cattle ('hard' production technology) and on beef cost analysis ('soft' managerial technology) showed that farmers construed these technologies differently, using multiple criteria both economic and

non-economic. They also demonstrated that both adoption and non-adoption resulted from elaborate decision processes and were rational given the farmers' understanding of these technologies and their current resource set. Both adoption and non-adoption occurred for diverse reasons. Reasons for non-adoption included the technology incompatibility with the farmers' goals and values or with their farming systems, constraints to adoption or because the technology was perceived as less advantageous than other alternatives.

These findings contribute to decision making and technology adoption theories, drawing attention to the need of a 'farmer-centric' approach in the development and diffusion of technologies. Under a 'farmer-centric' approach, it is acknowledged that farmers are unique, have diverse goals and farming systems and these impact on how they perceive technologies. It is argued, therefore, that by better understanding the decision frameworks of these innovative farmers, research institutions can design more effective research and extension strategies.

Keywords: Adoption of innovations, Agricultural research, Beef cattle, Decision making, Ethnographic Decision Tree Modelling, Farmers' goals, Grounded Theory, Q-Methodology, Social-psychology, Soft Systems Thinking, Technology adoption and Technology transfer.

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Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

1.1 Preview

Research has been carried out worldwide on farmers' technology adoption behaviour. Several technologies have been investigated and various factors affecting the adoption decision have been analysed. However, in most studies a research paradigm that focused on the average or aggregate behaviour prevailed. While this research paradigm had significant contributions to knowledge and agricultural advancement, particularly in the natural sciences, on its own it proved to be insufficient to understand people's (e.g., farmers) complex and unique nature. The acknowledgment that farmers are diverse, have different motivations for farming and, therefore, behave differently when facing similar situations has given rise to several theories on farmers' decision making. Thus, the ways of thinking and construing agricultural research, particularly within the social sciences, have evolved, becoming more socially grounded and culturally sensitive. In this context, the need for understanding the various groups of farmers, their diverse 'realities', beliefs, aspirations and behaviours has become more appealing.

Traditionally, agricultural research has focused either on disadvantaged farmers (e.g., subsistence farmers) or on modal, typical or 'average' farmers, given they make up the majority of farmers and therefore are relevant from a policy point of view. One group of farmers that have been overlooked by agricultural researchers, particularly in Brazil, is the innovative farmer. Perhaps, a perception that these farmers are 'doing well' explains the lack of social science research interest. However, innovative farmers are an important group to be investigated because they are likely to be open to try and adopt new agricultural technologies, being the primary target market for agricultural research institutes. They may also play a critical role in importing technologies from research institutes into the production sector and, more importantly, being benchmarks to other farmers. For these reasons, this research focuses on this strategic group of farmers. Specifically, innovative beef farmers were chosen as the research unit since the beef industry contributes significantly to the Brazilian economy, as is discussed in the next chapter.

This research undertakes a qualitative approach to develop rich pictures of how and why Brazilian innovative beef farmers make adoption decisions, which ultimately determine their technology adoption and non-adoption behaviours. Therefore, this study is directed towards theory building rather than theory testing (i.e., inferential statistics). In order to get farmers' accounts on technology adoption, a case study with 26 innovative beef farmers in *Mato Grosso do Sul* State, Brazil, was undertaken through face-to-face interviews and participant observation during visits to their farms. Farmers' prevailing goals and values are identified, grouping farmers with similar views. Within groups, goals are compared with actual adoption behaviour so that relationships can be analysed. Farmers' actual adoption behaviour is mapped out using 45 production, environmental and managerial technologies, upon which farmers' technological profiles are drawn. Additionally, a case study of two contrasting technologies is carried out in an attempt to gain insights on the decision-making processes of these innovative farmers. The results of this research are expected to contribute significantly to the current body of knowledge on technology adoption and decision-making. It is also intended to support policy-makers and agricultural researchers in delivering sound policies and technologies, respectively.

In the next five sections of this chapter, general issues of relevance to this research are briefly discussed. It starts with some important background, including a review of the evolution and restructuring of agricultural research and development (R&D) in Brazil; views on technology, innovation and innovativeness; and, the innovative beef systems in Brazil. Next, the research questions and objectives are defined, followed by a summary of the main justifications for this study. Subsequently, the scope and delimitations of this research are highlighted and, finally, the thesis outline is presented.

1.2 Research Background

Three topics provide the necessary background to this research: (1) agricultural research and development (R&D) in Brazil; (2) technology, innovation and innovativeness; and, (3) the Brazilian beef industry. The first topic traces the evolution of agricultural research and technology transfer in Brazil, setting the institutional context for technology diffusion and adoption. Next, technology, innovation and innovativeness are defined and the implications of these constructs for this study are discussed. Finally, a brief overview of the innovative beef systems in Brazil is presented, given this research focus on innovative farmers. More details on the Brazilian beef industry and farming systems in particular are covered in Chapter 2.

1.2.1 The evolution and restructuring of agricultural R&D in Brazil

The first attempts of biological research in Brazil began in the 1800's at the Botanic Garden of Rio de Janeiro. However, it was not until mid-1900's that research became more agronomically-oriented. In 1887, the Imperial government established the first Brazilian research institute, the Imperial Agronomic Station of Campinas, later renamed Agronomic

Institute of Campinas (IAC) which is still in operation (Beintema, Pardey, & Ávila, 2006). Later, other research institutes were established but they were limited in scope (i.e., focus on a few agricultural products) and geographic representation, being concentrated mainly along Brazil's coast. (Lopes & Arcuri, 2010).

In the mid-1960's and onwards, a remarkable modernisation of the Brazilian agriculture took place by means of substantial government interventions. Agricultural policies, such as subsidised rural credit programmes and price support mechanisms (Chaddad & Jank, 2006), including a *"Warranty Policy for Minimum Prices"* (Lopes & Arcuri, 2010, p. 3), were established. These policies, along with the worldwide spread of the ideas embodied by the 'green revolution', triggered the demand for agricultural knowledge (Lopes, 2010). The Brazilian Agricultural Research Corporation – EMBRAPA – and the Enterprise for Technical Assistance and Rural Extension – Embrater – were created in the 1970's to coordinate the national agriculture research and technology diffusion, respectively (Lopes & Arcuri, 2010). EMBRAPA along with State research institutes and federal and State agricultural universities gave rise to the National System for Agricultural Research (SNPA). Abundant public funding, during the 1970's and part of the 1980's, enabled EMBRAPA to achieve significant research results (Beintema, Pardey & Ávila, 2006) and extension services to reach approximately 78% of all Brazilian municipalities (Lopes, 2010). In this period, agricultural production increased mainly through its expansion towards Central Brazil.

However, the debt crisis and a persistent high inflation during the late 1980's led to a decrease in public investments in agriculture, including research and extension services (Chaddad & Jank, 2006; Lopes & Arcuri, 2010). Embrater was closed in the early 1990's and EMBRAPA went through internal restructuring to refocus its research priorities and foster national and international partnerships. At a State level, several agricultural research agencies were closed or merged with extension agencies (Beintema, Pardey & Ávila, 2006).

In mid-1990's, an economy-wide structural reform took place and commodity markets were liberalised and deregulated (Chaddad & Jank, 2006; Lopes & Arcuri, 2010). There was a major shift in the government's role from an interventionist to a regulatory approach that impacted not only research and extension programmes but the whole agriculture sector. The result was a massive 'competition shock', followed by significant modernisation and industrialisation of the Brazilian agrifood sector (Chaddad & Jank, 2006).

Competitiveness arose as the new paradigm for farmers, who responded accordingly. The exposure to international markets propelled them to target productivity increase, investing in technology. Particular attention was given to technologies adapted to the conditions of the Brazilian *Cerrado*[1], which, along with some remaining compensation policies, allowed further expansion of agriculture to Central Brazil (Lopes & Arcuri, 2010). The SNPA also played a relevant role in developing and promoting a wide range of agricultural technologies. The conjoint efforts of public institutes, universities, non-governmental organisation, and increasingly, private companies, led the SNPA to become *"one of the largest agricultural research networks in the tropical world"* (Lopes & Arcuri, 2010, p. 3, building on various authors).

EMBRAPA is the major component of the SNPA, with 15 central units and 37 research centres, accounting for 72 percent of the government agricultural R&D spending (Beintema, Pardey, & Ávila, 2006). It is *"the largest agricultural R&D agency in Latin America in terms of both staff numbers and expenditure"* (several authors cited in Lopes & Arcuri, 2010, p. 3). Given its importance to the Brazilian agricultural research, EMBRAPA's agenda for R&D is largely influential to the entire SNPA and is likely to direct most of the future agricultural research, development and innovation in Brazil.

In its last strategic planning report, comprising the period of 2008-2011 and long-term views for 2023, EMBRAPA emphasised the importance of agriculture sustainability for Brazil and pointed out how this new paradigm is to be incorporated into EMBRAPA's research agenda (EMBRAPA, 2008). Under the sustainability paradigm, EMBRAPA's research programme is not only concerned with food production or competitiveness, but more importantly, with the establishment of the grounds for the sustainable use of natural resources. This includes research, development and innovation on the reduction of environmental impacts of agriculture, more efficient allocation of resources, the development of renewable energy sources, sustainable use of biomes and regional integration, promotion of organic and ecological production systems and use of biotechnology.

Given EMBRAPA's research-driven approach, the technology transfer (TT) area has been historically neglected within the company (EMBRAPA, 2009). In acknowledgement to the importance of technology diffusion and innovation to the Brazilian agriculture, as well as in recognition of this historical lack of priority on TT, EMBRAPA's board of directors started a restructuring of this area in 2009 (EMBRAPA, 2009). Moving away from linear models, the new framework called for an integrated approach between research development and

[1] According to Portal Brasil (2010a), the *Cerrado* is the second largest Brazilian biome, also known as Brazilian Savannah given the prevalence of this type of vegetation. It covers some 22% of the Brazilian territory, occurring mainly under hot sub-humid tropical climate, with average temperatures ranging from 22 °C to 27 °C.

technology diffusion, with higher participation of stakeholders from the prospective stage of technological research to its validation on the field (Lopes, 2010).

The central role of stakeholders in this new research paradigm means that research demands should be context-sensitive, guided by their needs and aspirations, and taking into account their culture and empirical knowledge (Lopes, 2010). Nonetheless, the challenge remains as to how to involve stakeholders in the research process (EMBRAPA, 2009; Lopes, 2010). Some researchers suggest open communication channels and participatory research methods (Cezar, 1999; Lopes, 2010). Another alternative is to promote research that enhances the understanding of the various groups of stakeholders (e.g., farmers), their diverse realities and their technological demands (i.e., market segmentation). The latter relates to the approach undertaken by this research.

1.2.2 Technology, innovation and innovativeness

In this section, the concepts of technology, innovation and innovativeness are presented and the definitions relevant to this thesis appointed. This is necessary in order to emphasise some less evident aspects of innovations and avoid misinterpretation in future chapters.

The dictionary definition of technology is *"the practical application of knowledge especially in a particular area"* or *"a manner of accomplishing a task especially using technical processes, methods, or knowledge"* (*Merriam-Webster*). The same dictionary defines innovation as *"the introduction of something new"* or *"a new idea, method, or device"*. By implication, an innovation can be seen as a particular case of a technology, i.e., one that is new. According to Rogers (1962, 2003), the newness of an innovation, or technology, is determined by the person perceiving it. Thus, if a technology is tried for the first time by a user it is an innovation for that user, irrespective of the time it was launched or first used in a social system.

Given that most diffusion studies deal with technological innovations, technology and innovation have been commonly used as synonyms (Rogers, 2003, p. 12). In this research, innovation and technology are also used interchangeably. It is possible, however, to identify other definitions of innovation in the literature. For example, Schumpeter (1934) defines innovation as having five dimensions: (1) the introduction of a new good; (2) the introduction of an improved method; (3) the opening of a new market; (4) the use of a new supply of raw materials; and (5) the better organisation of an industry. Hurley and Hult (1998), based on several authors, discuss innovation as a process by which organisations continuously implement new ideas, methods, products or services in order to keep competitive.

The definition of both technology and innovation, as above, encompasses two components: ‘hardware’ and ‘software’. The former is the physical object that embodies the technology whereas the latter refers to the information upon which a technology runs (Rogers, 2003, p. 13). According to Rogers (ibid), technology is usually thought of as hardware, although sometimes it can be almost completely based on information. Building on the ‘hard’ and ‘soft’ nature encompassed by technologies, Jin (2002) describes ‘hard’ technology as consisting of the material object (i.e., tangible entity) and ‘soft’ technology as the intellectual technology or, in other words, the knowledge (i.e., intangible entity) applied to solve problems. Examples of predominantly ‘hard’ and ‘soft’ technologies applied to farming systems are grass seeds and budgeting, respectively.

Technologies vary not only in nature (e.g., ‘hard’ and ‘soft’) but also in the area of application. Different types of technologies focus on different areas of the farm business, such as production, environment and management. Although there are no clear boundaries whether a technology is production or environment related, given their intertwined character, in this research a distinction is made based on the primary focus of particular technologies. Thus, production technologies are mainly directed to increase meat quality, cattle production and/or productivity. In contrast, environmental technologies essentially focus on the conservation of natural resources and the mitigation of environmental impacts. These definitions were used here to allow for methodological treatment, even though it is acknowledged environmental technologies also impact on beef production, particularly in the long run. For instance, whether soil conservation practices are production or environmental technologies is debatable. Given soil conservation practices mainly aim at preventing soil erosion, they are here considered an environmental technology. The third group of technologies is managerial. These technologies aid decision making, business administration and marketing. They focus primarily on supporting the organisation and control of the farm business in order to improve its efficiency, reduce costs or increase margins.

By definition, production, environmental and managerial technologies can be either predominantly ‘hard’ or ‘soft’. A system to categorise technologies can be then represented by the various possible combinations of the types of technologies (e.g., predominantly production, environment and managerial) and their nature, i.e., a continuum from predominantly ‘hard’ to predominantly ‘soft’. This is illustrated below (Figure 1.1).

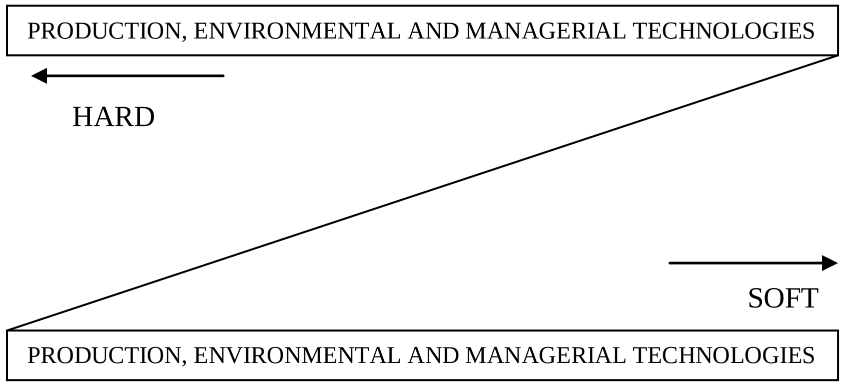

Figure 1.1 Categories of technologies

The introduction of the nature and type of technologies is relevant in the context of this thesis because the definitions above are used to determine whether each technology analysed in Chapter 7 is of the production, environmental or managerial type. More importantly, in the case study presented in Chapter 8, the discussion on decision making is based on farmers' adoption behaviour related to a 'hard' production technology and a 'soft' managerial technology. The conclusions, therefore, take into account the specific types and nature of these technologies.

Innovativeness is another construct important to this study. According to Rogers (2003, p. 280) innovativeness is *"the degree to which an individual (...) is relatively earlier in adopting new ideas than other members of the social system"*. While this definition is useful to understand the diffusion (i.e., adoption rates) of a particular technology, it provides a fragmented view of individuals making adoption decisions. For instance, the same individual can be an 'innovator' when it comes to technology 'A' but a 'laggard' in respect to technology 'B' (see Rogers, 2003 pp. 282-284 for more on adopter categories). A more holistic approach is required when it comes to human nature. Therefore, innovativeness is considered in a broader sense, as Hurley and Hult (1998, p. 44) proposed: *"it is a notion of openness to new ideas"*. This definition encompasses not only one's overall willingness to uptake technology (both 'hard' and 'soft'), and take risks, but also his/her personal commitment to make things differently from others. This perspective of innovativeness justifies the sampling frame undertaken in this study, as it is explained in Chapter 5.

1.2.3 Innovative beef systems in Brazil

Brazil has the largest commercial cattle herd of the world, with an estimated 205 million in 2009, of which 74 percent were beef cattle (IBGE, 2009). Brazil is currently the world's second largest beef producer and the largest exporter (ABIEC, 2010b). This performance is a consequence of agro-climatic conditions, agricultural policies, demand factors, modernisation of processing sector, research and extension, and technology adoption. Major historical technology adoptions included the Indian Zebu cattle (*Bos indicus*), that were introduced into Brazil in the late 1800s, and improved grasses, such as *Brachiaria decumbens* and, later, *Brachiaria brizantha* (Costa, 1998). The ready adaptation of both imported cattle and grasses to Brazil's tropical conditions allowed a rapid expansion of cattle herds throughout the Brazilian *Cerrado*. There are also many more recent innovations available to beef farmers, encompassing production, environmental and managerial technologies.

Although the Brazilian beef sector has been experiencing rapid development at an aggregate level, development across individual farms has been heterogeneous. The diverse outcomes in part reflect differences in farm business structures spanning subsistence farms, commercial family farms and corporate farms, together with a range of objectives that influence adoption and investment behaviours. They also reflect different environmental conditions and hence a range of beef production systems.

Brazilian beef systems have been described based on different criteria. Steiger (2006), for instance, applies the land size (i.e., small and large landowners) as a criterion on which to debate government policies and the implications for the beef industry. Bastos (1980) and Chaddad and Jank (2006), building on the land size dichotomy, add another criterion, that is, the purpose of farming: subsistence versus commercial. The former is associated with small farms whereas the latter relates to large farms. Cezar (1999) considers the stages of beef cattle production to define the beef systems. These include cow/calf, rearing and fattening, which can be run separately or in combination. Cezar *et al.* (2005), in turn, describe beef production systems based on the prevailing dietary system and the level of inputs. These include: intensive, semi-intensive and extensive systems. Intensive and semi-intensive systems are reliant on the intense use of working capital, particularly for feedstuff (Cezar *et al.*, 2005) whereas extensive systems are commonly characterised by large areas of land exploited with low working capital (Costa, 1998). Lastly, Michels, Sproesser and Mendonça (2001, p. 128) draws attention to traditional beef systems, with their description adhering almost completely to the description of extensive systems (above). The explanation for this congruency may be provided by Costa's (ibid) assertion that beef production has been historically established through semi-extractive use of native pasture with low levels of inputs. No mention was found to innovative beef systems, however.

Innovative beef systems are only implied by the existence of a traditional beef system, to which they contrast[2]. However, there is a lack of theoretical grounds to identify and characterise innovative beef systems in Brazil. A search for Brazilian progressive, entrepreneur, innovative or leader farmers, and variants, on databases including CAB, Pro-Quest, Web of Science, Science Direct and Google Scholar had poor results. This may be due to a lack of interest in these types of farmers, given research typically problem-solving in nature (and an assumption that these groups are 'doing well'). This can also result from mis-specification of the study's target group. For instance, Pereira, Vale and Mâncio (2005b) analysed top beef farmers involved with high genetic merit herds in the *Triângulo Mineiro* region, Brazil, despite the title not providing any cue of this.

Using common sense, innovative systems tend to be seen as those more technologically advanced, as is the case of intensive and semi-intensive beef systems. Although this may hold some truth, there is a strong pro-innovation bias underlying this assumption. It assumes that innovativeness is the same as adoption, and overlooks non-adoption as a considered state. However, as discussed in the previous section, innovativeness goes beyond adoption (action) to involve individual's openness to new ideas in general (state of mind). Moreover, considering that there are 'hard' and 'soft' technologies, innovative systems are likely to heavily rely on both. As 'hard' technology is more observable, the common association between innovative systems and [hard] technology-based system is justified.

In this research of innovative beef farmers, the assumption of innovative systems consisting of intensive and semi-intensive systems is put aside. Farmers are primarily selected for their innovativeness based on their differentiated behaviour relative to the majority of farmers; their beef systems are described *ex post*. Rather than focusing only on adoption, this study also pays particular attention to non-adoption behaviour, which explains why this is made explicit in the title up to the conclusions of this study. Methodological implications of such a paradigm are discussed in Chapter 5.

1.3 Justification for the Study

One factor influencing farm performance is the level of technology uptake. In order to promote the adoption of technologies and increase farm performance, several Brazilian studies have been undertaken highlighting current or potential benefits of innovations. Generally, these studies have focused on production efficiency (Abreu, Lopes, Torres, & Santos, 2006; Amaral, Corrêa, & Costa, 2005; Poli & Carvalho, 2001) and profitability

[2] This duality of constructs is supported by the Personal Constructs Theory, which is explored in Chapter 3.

(Dossa, 2000; Jorge Junior, Cardoso, & Albuquerque, 2007). Despite the benefits reported by researchers, the uptake of technology remains uneven among various groups of beef farms in Brazil (e.g., traditional versus innovative; commercial vs. subsistence; intensive vs. extensive; small vs. large).

Drawing on international adoption literature, several hypotheses can be formulated to explain such uneven technology adoption. These include the differences in the capital constraints, technology characteristics (Rogers, 2003), farmers' limited access to information (Cezar, 1999; Rogers, 2003), farmers' socio-psychological characteristics (Beedell & Rehman, 2000) and many other aspects. Farmers' socio-psychological aspects, including farmers' values, beliefs, personalities, motivations and attitudes, have increasingly been capturing the attention of some scholars (Bigras-Poulin, Meek, Blackburn, & Martin, 1985; Burton, 2004). In socio-psychological studies the aim is usually to identify latent variables (i.e., non-observable variables) relevant to the adoption behaviour and sometimes measure their effect upon this behaviour. Other studies, also drawing on socio-psychology, may use cognitively-based models to try to gain insights on one's mental process determining adoption behaviour, such as illustrated in the work by Gladwin (1989).

In Brazil, the literature on farmers' socio-psychological aspects influencing adoption and non-adoption of technology is very limited. According to Edwards-Jones (2006), to overlook the role of socio-psychological aspects in adoption decisions leads to a misinterpretation of farmers' rationality. This, in turn, creates a lack of understanding of the relevant decision criteria for farmers themselves. Traditionally, adoption studies on Brazilian farmers have focused on other aspects influencing technology adoption, such as: agricultural policies (Bastos, 1980), price variations (Araújo, 1995; De Souza Filho, Young, & Burton, 1999), access to information, communication systems and extension services (Brandão & Dall'Agnol, 1981; Strauss *et al.*, 1991), social influences (Jill, 2003) and farmers' socio-economic profile (Partelli *et al.*, 2006). Despite providing relevant information for policy makers, the reductionist approach undertaken by these studies offer partial views on adoption and may be not appropriate for the understanding of complex issues, such as the adoption decision making process.

Given the complexity of adoption decisions, a holistic approach may be more appropriate, combining knowledge from different fields such as biological processes, economics, marketing, sociology, and psychology among others. Additionally, putting farmers first in the research enquiry should allow for further understanding of their behaviour. A holistic approach, coupled with a farmer first principle, makes a qualitative research enquiry particularly appealing.

Besides the methodological gaps identified above, there is also a lack of research on innovative farmers and farming systems, as discussed in the previous section. The relevance of this particular group of beef farmers relates to their role in the innovation process. Given they are open to new ideas, they are the main potential adopters of new technologies. Also, they are likely to browse information widely and interact with several other social actors, including researchers, extension professionals and other farmers, possibly 'making the bridge among them'. As a consequence, they may play a role in the diffusion process, by *"importing the innovation from outside of the [farming] system's boundaries"* and displaying it for other farmers (Rogers, 2003, p. 283), and by validating and giving feedback to researchers as well as by co-generating knowledge and technologies (Scoones & Thompson, 2009). A better understanding of innovative beef farmers' adoption behaviour is expected, therefore, to enhance the technology development and diffusion programmes of R&D institutions, including EMBRAPA.

In response to the issues and, in particular, to the gaps discussed so far, the overall research objective is to develop insights on Brazilian innovative beef farmers' adoption behaviour using a qualitative enquiry. Rather than testing prior theories, this study develops original understandings of these farmers' thinking, considering the social-psychological and economic aspects of their decision making processes.

In summary, the main justifications to undertake this research are the following.

1) There has been very little attempt to develop theories of farmers' decision making in the Brazilian context. Considering that decisions are context dependent, theories of decision making developed in other contexts, particularly in developed countries, may not be appropriate to explain Brazilian farmers' technological decisions. This study to some extent will fill this void.

2) Most extant studies present partial analysis of the decision making and the adoption processes (e.g., economic vs. psychological approach). There is therefore a need for more integrated, comprehensive and dynamic approach to decision making studies encompassing economic and socio-psychological factors, including farmers' goals and values. This study uses a holistic approach to cover all the relevant aspects, i.e., elicited from farmers, that impact on their technology adoption behaviour.

3) The Brazilian literature on farmers’ technology adoption proved to be very limited in scope, usually involving few agricultural products, but excluding beef. The limited studies are mostly quantitative in nature with a prevailing economic focus. Hence, there is a need to expand the horizon of analysis of farmers’ behaviour, taking into account not only other factors influencing their actions (social, psychological, environmental and others) but also other alternative models of inquiry such as the qualitative approach.

4) A strategic group for researchers to work with is the innovative farmers since they may be influential to other farmers and provide feedback on research results. Their openness to new ideas and technologies makes this group of farmers a primary target market for R&D institutions. To date, most studies overlooked innovative farmers and focused on average or modal farms. Hence, modelling innovative farmers’ decision making processes will provide insights on this under-researched but strategic group.

5) There is no evidence neither in Brazil nor internationally, that farmers’ decision making processes for different types of technology have been analysed and compared. There is, therefore, a lack of understanding whether or not farmers construe different technologies differently and, if so, if this difference explains different adoption decisions. This research will provide some insights on this topic.

This study should give significant contributions to the current body of knowledge regarding decision making and technology adoption, particularly of innovative beef farmers. Arguably, it may also support policy makers and researchers in developing sound policies and technologies respectively for the Brazilian beef farms.

1.4 Research Questions and Objectives

The overall research question to be addressed by this study is: **How and why do Brazilian innovative beef farmers make decisions about whether or not to adopt particular technologies?** In order to answer this question the following subsidiary questions will also be addressed:

1. Is there diversity of major goals and values amongst Brazilian innovative beef farmers, and if so, how can this diversity be characterised?
2. How does diversity within innovative beef farmers’ goals and values affect adoption and non-adoption of technologies?

3. Do innovative beef farmers use a different set of constructs when assessing different types of technologies? If so, why?

To deal with such research questions, this study establishes six research objectives (below). The first research objective is set out to answer research question 1, research objectives 2 and 3 to answer research question 2 and the remaining research objectives address research question 3.

1. Map, compare and contrast Brazilian innovative beef farmers' goals and values.
2. Identify which technologies have, and which have not, been adopted by innovative beef farmers.
3. Identify types of technology that have been adopted by particular groups of farmers (i.e., defined by their major goals and values) and establish relationships, where appropriate.
4. Model decisions on one production and one managerial technology.
5. Compare constructs used by innovative beef farmers that justify adoption and non-adoption of these two contrasting technologies.
6. Describe the main factors influencing decision making on technology uptake or rejection.

1.5 Research scope and delimitations

While it is acknowledged that several factors influence technology adoption decisions, as discussed in previous sections, an attempt to address all of these conditioning factors is quite unrealistic if depth of study is to be achieved. Furthermore, in choosing farmers' goals and decision-making processes, this study emphasises the human perspective of technology adoption rather than external factors that influence this process.

Research on innovative farmers is conceptually original in the sense that it goes beyond farm sizes or production systems. Since research units are selected mainly based on the farmers' innovativeness, research of innovative farmers can potentially include any type of farm. Operational difficulties of using innovativeness as a selection criterion impede the determination of the size of the population of innovative farmers and, therefore, the representativeness of samples. Given the small sample studied here (26 innovative farmers), caution is needed for extrapolation of results. Nevertheless, findings can be extrapolated to theories on decision making and technology adoption.

Finally, the study area is limited to *Mato Grosso do Sul* State, in the Brazilian Center-West region, given this State's leading position in the country's beef production (presented in Chapter 2). Within *Mato Grosso do Sul* State, only farms under the *Cerrado* ecosystem were selected for this study because of the relevance of this ecosystem for the Brazilian agricultural production. The *Pantanal* ecosystem, which is another major ecosystem of *Mato Grosso do Sul* State, is beyond the scope of this research. The *Pantanal* environment imposes several constraints to beef production systems, limiting the options for farmers' decisions on technologies. Moreover, given the differences in the socio-cultural settings under the *Pantanal* ecosystem, results could differ dramatically.

1.6 Thesis Outline

This thesis has nine chapters. An overview of this research, including key definitions, and the research objectives have been presented in Chapter 1. In the next three chapters, literature of relevance to this study is reviewed. In Chapter 2, the Brazilian beef industry is described, with particular emphasis on beef production systems. Technology adoption among Brazilian farmers is also discussed in this chapter. Chapter 3 reviews theories and models related to decision-making processes, particularly those of interest to technology adoption. Chapter 4 presents the main factors that have been reported by scholars in various countries to be influential on farmers' technology adoption. This chapter establishes, therefore, the 'state of art' on technology adoption worldwide, providing the basis for the discussion of the results in later chapters.

Chapter 5 outlines the research approach and methods. It includes the research strategy, procedures for data collection and analysis, ethical considerations and methodological limitations.

The thesis results are presented in the subsequent three chapters. Chapter 6 identifies farmers' prevailing goals and values, which are the basis for farmers' grouping. These groups are then used in Chapter 7 to analyse whether innovative farmers in different groups (i.e., with different goals) have diverse adoption behaviour. Farmers' technological profiles are built and discussed in the light of previous findings and the farmers' explanations for their (non-) adoption of various technologies brought to discussion. Chapter 8 covers the adoption and non-adoption behaviours of innovative beef farmers using decision-making models on two contrasting technologies (a 'hard' production and a 'soft' managerial technology). Farmers' decision paths are mapped and, drawing on these, farmers' constructs are identified. Constructs for these two technologies are compared to provide accounts on how similar or dissimilar decision models are, and how the difference may help understanding the adoption decision. These findings are also analysed in the light of the results presented in Chapter 6.

Finally, Chapter 9 discusses the main findings of previous chapters in a holistic way. It reviews how research questions and objectives were met, highlighting the main contributions and conclusions of this study. It also explores the implications of the findings for both theory and practice, including implications for agricultural researchers, extension practitioners and policy-makers. Limitations of the findings are identified and topics for future research suggested.

Chapter 2
The Brazilian Beef Industry

2.1 Introduction

In the previous chapter, a preview of this research was presented, including a discussion on innovative beef systems in Brazil. In this chapter, a more comprehensive view of the Brazilian beef industry is considered and its importance emphasised. The aim here is to describe the relevant issues related to this industry, which influence, or are influenced by, beef farming systems.

Initially, the market environment, both domestic and international, is described, setting the scene for Brazil's current position in the global beef trade. The subsequent sections turn to the production sector. Given Brazil's vast territory and heterogeneity, the spatial distribution and dynamics of herds among Brazilian regions are explored. It follows that beef production systems are also diverse. Given this diversity, beef systems are first described in general terms and then specifically described for the Brazilian *Cerrado* ecosystem. Most agricultural production in *Mato Grosso do Sul* State, the study area, occurs under *Cerrado* conditions.

2.2 Macro-economic Aspects of the Beef Industry in Brazil

In 2009, the beef cattle production reached 6.7 million metric tons, placing the country as the second largest beef producer in the world, behind the United States of America (IBGE, 2009). From the total produced, 86% supplied the domestic market, with the remaining 14% being exported. Despite an export decrease of almost 10% compared to 2008 (ABIEC, 2010a), Brazil remained ranked as the world's leading exporter in 2009 (IBGE, 2009). According to FAPRI (2010), this fall in Brazilian exports was due to an overall weak demand worldwide and volume restrictions determined by the European Union. However, the same source estimates that Brazil will keep its leading export position for the next decade, increasing 6.4% from its current market share of 33%.

According to ABIEC (2010a), the Brazilian exports portfolio consists of processed beef (sausages and cooked meat), fresh chilled/frozen meat and edible offal. Fresh meat represented 75% of the total beef exports in 2009, with Russia, Iran and Hong Kong being the main importers. The exports of processed meat represented 13% and of edible offal 12%; the United States and United Kingdom were the main importers of the former, while Hong Kong imported mainly the latter. The average export price in 2009 was US$ 3,300/t, resulting in some US$ 4 billion of exports sales.

In the domestic scenario, historical unbalanced distribution of income has been a major factor limiting beef consumption, given meat's high income-elasticity (IEL, CNA, & SEBRAE, 2000; Pereira & Lima, 2000). However, government policies to alleviate hunger and improve social welfare systems have resulted in better income distribution over the last years, creating opportunities for a higher consumption of beef amongst Brazilians. For instance, the ratio between the *per capita* family income of the 20% richest and 20% poorest reduced from 24.3 to 17.8 between the years 2001 and 2009 (IBGE, 2010). Additionally, the percentage of families earning up to five minimum wages[3] per month decreased from 63 to 60 between 1999 and 2009. At the same time, the Brazilian *per capita* consumption increased from 37 kg/inhabitant in 1999 (FNP, 2007) to 41 kg in 2009 (FAPRI, 2010). This 41 kg *per capita* consumption contrasts with Argentinean *per capita* consumption of 64 kg but was similar to the USA consumption of 40 kg and higher than the Australian consumption of 35 kg (FAPRI, 2010).

In response to increasing demand, both domestically and internationally, the Brazilian beef industry has been expanding. For instance, Steiger (2006) estimated that between 1994 and 2005, Brazil increased its national herd by 24%, export volumes by 450%, and export values by 385%. Several factors contributed to such an expansion, including: continued availability of natural resources, competitive export prices due to favourable exchange rates and lower production costs compared to Brazil's main competitors (Tirado, Costa, Carvalho, & Thomé, 2008, p. 14), increasing domestic demand (Steiger, 2006, p. 107), and disease outbreaks in other countries, such as Foot-and-Mouth disease (FMD) in Argentina in 2000 and Bovine Spongiform Encephalopathy (BSE) in Europe, United States and Japan (Polaquini, Souza, & Gebara, 2006). In 2005, Brazil also faced a downturn in international beef market given outbreaks of FMD in *Mato Grosso do Sul* State (Steiger, 2006).

Some structural factors have had a significant influence on the industry performance in recent decades, particularly after the 1960's. At that time, agricultural policies based on subsidised credit, minimum prices and import substitution were established and agricultural research and extension had massive investments (Chaddad & Jank, 2006) supporting the beef industry in various ways. Farmers, for instance, benefited from abundant credit made available through

[3] The minimum wage in Brazil is established on a monthly basis. In September 1999, the Brazilian minimum wage was R$ 136.00 (US$ 71.32) per month. The minimum wage in 2009 increased to R$380.00 (US$ 199.28), which was above the accumulated inflation between 1999 and 2009.

several government programmes, such as: the National Pasture Programme (PRONAP), the National Programme for Beef Cattle Development (PROPEC) and the *Cerrado* Development Programme (PROCERRA) (Costa, 1998; Pinazza & Alimandro, 2000 as cited in Polaquini *et al.*, 2006, p. 323). Also, MODERFROTA, a programme aimed at farm machinery, allowed farmers to modernise their equipment at subsidised interest rates (Chaddad & Jank, 2006). Furthermore, the establishment and expansion of research institutes and extension services provided farmers with agricultural information and technologies, allowing farms to be brought into more intensive systems (see Chapter 1 for details).

The establishment of the Brazilian Agricultural Research Corporation - EMBRAPA - in 1973, and its Beef Cattle Research Unit, in particular, in 1974, along with increased investments in research within federal universities were fundamental for technology development aimed at the beef sector (Chaddad & Jank, 2006). Among major contributors to the diffusion of the new technologies were public rural extension services like the Technical Assistance and Rural Extension Corporation - EMATER - and the Coordination of Integral Technical Assistance of *São Paulo* State - CATI (Polaquini *et al.*, 2006).

The deregulation of the agricultural sector and the liberalisation of the Brazilian economy in the 1990's impacted significantly on the beef industry. A higher competition for international markets and the regulatory systems established in these markets, allied with a drastic reduction in government subsidies and support, resulted in major structural changes throughout the entire beef supply chain. To keep up with these changes and remain competitive, beef farmers engaged in more technologically-based systems (Euclides Filho, 2004), investing in tropical pastures, genetically improved cattle breeds, mineral supplementation and many other technologies. As a result, there was a considerable improvement in productivity. For instance, the average slaughter age has reduced from 54 to 38 months (Steiger, 2006). According to FAPRI (2010, p. 330), further improvements in productivity, among other factors, are expected, maintaining Brazil's competitiveness and leadership in the international beef trade.

Nonetheless, the Brazilian beef sector also faces some challenges due to its uncoordinated beef supply chain that may compromise its international leadership, if not properly addressed. Some 2.7 million farms with cattle as the main or the secondary activity (IBGE, 2009), 800 slaughterhouses, 798 leather processors and 7,562 shoes companies (MDIC, 2004), among other actors, make up the Brazilian beef supply chain. According to Vieira, Capacle, and Belik (2006), the relationship among these actors is often marked by informality and mistrust. Vertical integration of production is rare (Jank, 1996 as cited in Vieira *et al.*, 2006, p. 10), although some strategic alliances among beef producers, slaughterhouses and retailers have been increasing. One consequence of the lack of coordination of the beef supply chain is the difficulty in establishing and running traceability systems. In Brazil, traceability is partial, being compulsory only for beef producers and slaughterhouses accredited for exports (Souza-Monteiro & Caswell, 2004). The faulty communication between retailers and the processing sector, according to Jank (1996 as cited in Vieira *et al.*, 2006, p. 15), leads to uncoordinated actions by producers, who lack a full understanding of consumers' specific demands, both nationally and abroad. Therefore, a better coordination among the various components of the beef supply chain seems urgent (Euclides Filho, 2004; Steiger, 2006; Tirado et al., 2008).

Further development of the Brazilian beef sector also depends on the country's ability to expand the number of accredited farms to exports, widely implement traceability systems, improve the sanitary control and inspection by authorities (Euclides Filho, 2004; Steiger, 2006; Tirado et al., 2008), encourage more transparent relationship between farmers and slaughterhouses with the establishment of contracts (Vieira *et al.*, 2006) and internationally promote Brazilian meat (Steiger, 2006). At the farm gate level, the expansion of sustainable beef production systems also seems crucial (Euclides Filho, 2004).

2.3 Spatial Distribution and Dynamics of Cattle Herds in Brazil

A cattle herd of 205 million head, including beef (74%), dairy (20%) and dual purpose cattle (6%), are widely spread across Brazil (around 8,500,000 square km), reaching its 26 States (and the Federal District) that make up its five geographic regions (IBGE, 2009, 2011): North, Northeast, South, Southeast and Centre-West (Figure 2.1- A). Beef farming is found in all Brazilian biomes: Amazon (North), *Caatinga* (Northeast), *Cerrado* (Center-West), *Pantanal* (Center-West), Atlantic Rainforest (Southeast) and *Pampas* (South) (Figure 2.1 - B). For a description of these biomes, see Portal Brasil (2010a).

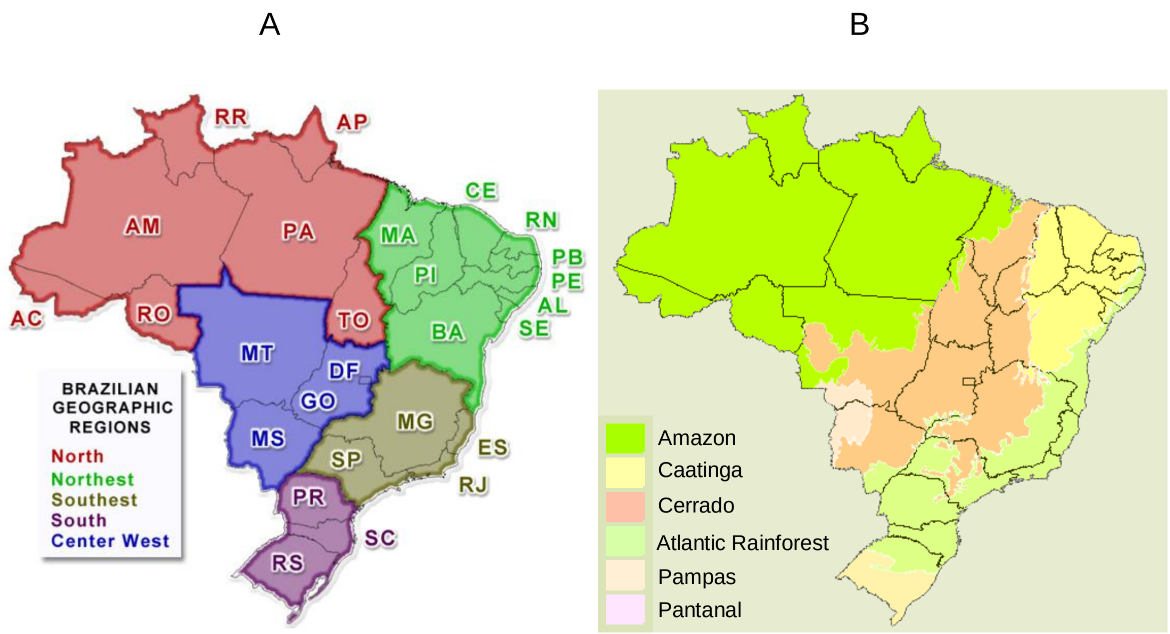

Figure 2.1 Brazilian geographic regions (A) and biomes (B)

Sources: (A) Cezar *et al.* (2005) based on IBGE (2005); (B) adapted from IBGE (2011).

The diversity of agro-climatic conditions, availability of natural resources, capital and infra-structure among Brazilian regions results in different challenges to the 2.7 million Brazilian rural properties with cattle production (IBGE, 2010), with beef systems responding accordingly (Cezar *et al.*, 2005; Michels *et al.*, 2001). This diversity also extends to the market environments, labour force, agricultural policies (i.e., regional policies), laws and regulations, and socio-cultural contexts, creating comparative advantages for particular regions or States (Michels *et al.*, 2006). All these factors combined explain most of cattle spatial distribution and the dynamics of herds throughout the Brazilian territory.

The distribution of the beef cattle herd in Brazil is heterogeneous, with 34% established in the Centre-West region (Table 2.1). Among the five Brazilian States with the largest cattle herd are *Mato Grosso* – MT (13%), *Minas Gerais* – MG (11%), *Mato Grosso do Sul* – MS (11%), *Goiás* – GO (10%) and *Pará* – PA (8%) (IBGE, 2009). In *Minas Gerais* and *Goiás* States, however, dairy makes up a large proportion of the herds, as these States are the country's main milk suppliers (LAEP, 2008).

Table 2.1 Regional cattle herd (millions) and cattle population growth rates (%) from 1999 to 2009

Regions	1999[1]		2009[2]		Growth (%)
	herd	%	herd	%	1999-2009
North	20.7	14	40.4	20	95
Northeast	23.9	13	28.3	14	18
Southeast	34.5	22	38.0	18	10
South	24.7	16	27.9	14	13
Center-West	53.1	35	70.7	34	33
Brazil	156.9	100.00	205.3	100.00	31

Sources: [1] Michels *et al.* (2006), based on MAA (2000); [2] Based on IBGE (2009)

The Brazilian cattle herd expanded around 31% between 1999 and 2009 (Table 2.1) as a result of the growth of regional herds; however, this regional growth varied considerably. Traditional cattle producers, such as Center-West, Southeast and South, had their participation in the national herd reduced while herds in the Northeast and North regions became more important. Furthermore, a significant growth rate in the North region revealed that cattle almost doubled in this region during the 1999-2009 decade. This herd dynamic suggests that there has been an expansion of herds towards the western side of the country, particularly in the North region, as illustrated below (Figure 2.2).

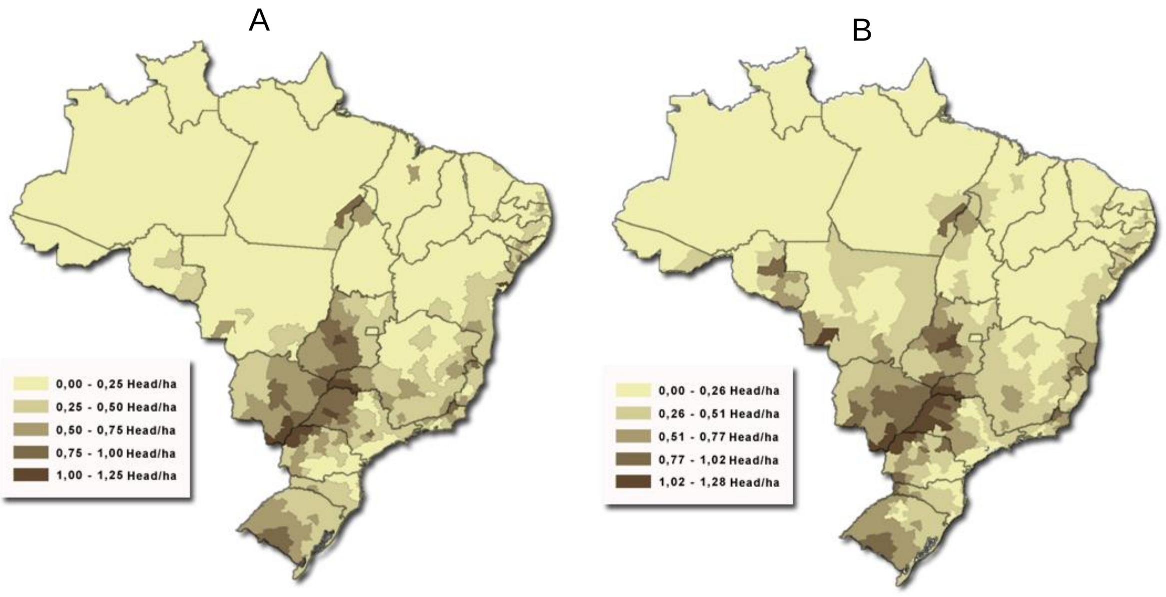

Figure 2.2 Beef cattle density in Brazil in 1993 (A) and 2003 (B)

Source: Cezar *et al.* (2005), based on IBGE (2005)

Steiger (2006, p. 107) explains the increase of the northern beef industry is a result of relative land prices. According to Steiger, the competition for land in the Centre-West has raised land prices in this region, making land in the North region more attractive to investors and profitability 10% higher. Land prices are likely to remain unfavourable to the CW region, given the increasing competition for land use. The Centre-West is the leading producer of oilseeds and is becoming a major producer of sugarcane and maize, in response to the emerging biofuel industry in the region (Knight, 2007).

The development of the regional beef industry in the North has not only capitalised on relatively low land prices but also on the increasing local demand for meat (Faminow, 1997). Faminow (1997, p. 2), studying beef farming in the Amazon, showed that the Amazon population and their purchasing power have risen significantly in the last few years serving as a 'powerful stimulus' to the cattle industry in this region.

Future dynamics of cattle herds in Brazil are likely to be influenced by further changes in the factors discussed and, more importantly, by growing environmental concerns. Whether these concerns will be transformed into effective policies is yet to be observed.

2.4 Brazilian Beef Production Systems

As presented in the previous section, beef farming in Brazil occurs in diverse agro-ecological systems, which bring different challenges for farmers. In response, beef production systems vary accordingly, encompassing farmers' diverse objectives, socio-economic conditions, cultural background, resources, and constraints among other factors. Cezar's (1999) study illustrates this phenomenon by comparing beef farmers in the *Pantanal* and *Cerrado* regions, both in *Mato Grosso do Sul* (MS) State. Cezar found that beef farmers in the *Pantanal* region had large farms (11,000 ha) and typically ran a cow/calf enterprise, sometimes combined with the rearing phase, mainly on natural pastures under continuous grazing. In contrast, farmers in the *Cerrado* part of MS, had 2,000 ha mostly with sown pastures. Most of them ran complete cycle systems with a well established breeding season and supplied cattle with mineral supplements all year around. Another difference was the farmers' objectives with farmers in the *Pantanal* region valuing the farming lifestyle and family tradition, as farms were mostly inherited, but the majority of farmers in the C*errado* region purchased their farms and valued farming as a safe business.

Given the diversity of beef farming systems, researchers have used several criteria to characterise and analyse beef production systems. The prevailing dietary system and level of inputs determine whether the beef farming system is intensive, semi-intensive or extensive.

Cezar *et al.* (2005) present a comprehensive review of these beef systems. According to them, intensive systems rely on intense use of working capital, particularly for feed purposes. Within this system, cattle are fed all year round in feedlots with high levels of concentrates or finished under highly productive pastures supplemented by concentrates or silage. In semi-intensive systems, pasture is the main source of feed, which is combined with alternative protein and/or energy sources to complement the diet, usually during the dry season. Some level of pasture maintenance is often observed in these systems. In contrast with the previous two, extensive systems are commonly characterised by low input of working capital and large areas (Costa, 1998) usually established with low quality perennial pastures, both native and sown (Cezar *et al.*, 2005). Under this system, cattle remain in an exclusive pasture-based regime.

According to Cezar *et al.* (2005), extensive grazing has been the prevailing regime in some 80 percent of beef farms throughout the country. The semi-intensive system has been predominantly found in central-southern Brazil, although it can be observed in a small proportion in the North and Northeast regions. *Mato Grosso do Sul*, *Mato Grosso*, *Goiás* and *São Paulo* States account for 90% of the total semi-intensive production in Brazil. These States also hold most of the intensive beef systems. Cavalcanti and Camargo (2007), analysing the 50 largest Brazilian feedlots in 2006, noted that these were mainly located in the States of *São Paulo* (34%), *Goiás* (28%), *Mato Grosso* (18%), *Mato Grosso do Sul* (16%) and *Minas Gerais* (4%). *Goiás* ranked first in terms of herd size under feedlot systems (48% of the total animals). A representation of the spatial distribution of these beef systems is illustrated in Figure 2.2 (above). In extensive systems, the density of cattle (head/hectare) is low whereas the density increases as the level of intensification of the systems grows.

Despite the historical prevalence of extensive system, national slaughter statistics have shown an increase in finished cattle under intensive and semi-intensive systems. Polaquini *et al.* (2006, p. 325), based on FNP (2002), reported that 825,000 head were finished in feedlots and only 250,000 under semi-intensive systems in 1992. In 2005, these figures were 2.3 million head and 2.6 million head (FNP, 2007) respectively, which represents an increase of 179 % for cattle finished under intensive systems and 940% for cattle finished under semi-intensive systems. According to Euclides Filho (2000), this process of beef farming intensification is likely to continue as the increasing beef demand and the higher competition in global markets call for more efficient and sustainable use of resources, leading farmers to invest in technology.

Another criterion to define beef systems in Brazil is based on the phases encompassed by beef farming: cow/calf, rearing and fattening. These phases can be carried separately or combined, as Cezar *et al.* (2005) and Michels *et al.* (2001) described.

- Cow/calf: all weaners are sold at 7 to 9 months of age, with some yearling heifers selected for breeding purposes. Heifers may also be sold as breeding cows to other farmers.
- Cow/calf and rearing: it differs from (a) in that store steers are sold at 15 to 18 months of age to other farmers.
- Cow/calf, rearing and fattening: the so-called ‘complete cycle’ system is the most common beef farming system. Within this system, cattle are sold to slaughterhouses at ages ranging from 15 up to 42 months, depending on the dietary system (as explained above).
- Rearing and fattening: farmers buy weaners, rear and sell them finished to slaughterhouses. Ages at slaughter depend on the production system, particularly the dietary system.
- Fattening: Traditionally it involved the purchase of 24 to 36-month cattle to be finished. However, the reduction of the length of the rearing phase as well as the risks involved with the supply of store cattle (i.e., shortages) have been reducing this phase as a sole activity.

Additionally, technological levels can be used to describe beef farming systems as the diversity of Brazilian beef production systems is in part related to the level of technology adoption. Technological levels are remarkably variable amongst Brazilian farms and spread on a continuum with farms ranging from very rudimentary and low-input based to modern technologically-driven farms (Cezar, Costa, & Pereira, 2004, pp. 524-525).

Several studies have illustrated this contrasting reality of Brazilian farms (Corrêa et al., 2005; Costa, Corrêa, Melo Filho, Cezar, & Pereira, 2005a; Costa et al., 2005b; Melo Filho et al., 2005; Pereira et al., 2005a). Examples include a study by Feitosa (2003) on 50 family farms from rural settlements, established by the Government land reform programmes in *Pará* State, Northern Brazil. Despite the original objective of researching ‘dairy’ farmers, results showed that beef cattle breeds were used for milk and meat production (i.e., dual purpose cattle). On average, a 69-hectare farm with 47 ha of pasture held 54 cattle whose average daily milk production was of 2.5 litres. According to Feitosa (ibid), the low productivity resulted from a prevailing low-input system given farmers' financial constraints. Overgrazed and degraded pastures were managed with the use of fire, mineralised salt was supplied to cattle only occasionally, and infra-structure was precarious and inappropriate to cattle handling and human safety. Vaccination was the only sanitary practice undertaken by farmers as it was compulsory. In contrast, Corrêa *et al.* (2005) described a typical (i.e., modal) beef farm also in *Pará* State: it ran a complete cycle of beef production (previously described) on 4,500 hectares, of which 50 percent was legal reserve, as determined by environmental laws. Continuous grazing was predominant alongside mineralised salt, resulting in an average carrying capacity of 0.75 AU[4]/ha/year. A level of pasture degradation was observed. Natural mating and a fixed breeding season were common as well as the use of pregnancy and bull fertility tests, resulting in a calving rate of 70 percent. Decision making was essentially intuition-based as there was a lack of record keeping and formal planning. This description of the typical beef farm in '*Pará*' is compatible with the mid-range of the technological continuum, mentioned above.

An illustration of the high-end of this technological continuum is provided by Pereira (2001), who analysed 46 breeding beef farms (studs) from the '*Triângulo Mineiro*' region of *Minas Gerais* State, Brazil. Pereira found that several production technologies were highly adopted by these breeders, including: artificial insemination (79% of farmers), breeding season (56%) and bull fertility test (around 40%). Furthermore, managerial technologies regarding the farm personnel (the focus of the research) were also adopted by most farmers and included, for instance, training and performance-based reward systems. Pereira concluded that the higher performance of these farms, in comparison to the regional farming performance indicators, was due to their major use of technologies.

2.4.1 The special case of beef systems under the *Cerrado* ecosystem

With an estimated area of 200 million hectares, of which 55 million are sown pastures, most of the Brazilian Savannahs (75%), the so-called *Cerrado,* cover the Central Brazil (Cezar *et al.*, 2005; Costa, 1998). According to Costa (1998, p. 4), the *Cerrado*, along with the *Pantanal* biome, makes up a region informally known as 'Brasil Central Pecuário' (BCP)[5] due to the outstanding importance of cattle for this region. The BCP includes the States of *Mato Grosso do Sul* (MS), *Mato Grosso* (MT), *Goiás* (GO) and *Tocantins* (TO), west of *São Paulo* (SP) and south-west of *Minas Gerais* (MG), covering some 2.7 million sq. km.

[4] A breeding cow weighting 450 kg is equivalent to 1 AU, that is, animal unit.
[5] '*Pecuário*' means devoted to cattle production. Given a major overlap (75%) of the areas covered by the BCP and the *Cerrado* region, Costa's (1998) review on the beef systems in BCP is taken here as an approximation of the beef systems in the *Cerrado* region.

A tropical climate prevails in the *Cerrado* region, with an average temperature of 22 to 24°C (Corrêa, 1994, cited in Costa 1998). The soils are generally infertile and acidic (Cezar *et al.*, 2005; Costa, 1998). The wet season is from October to April, when 80% of the annual precipitation (1,300–1,950 mm) occurs. The dry season (from May to September) is considered the main physical-biological bottleneck for grazing systems in this region (Costa, 1998).

There are several beef production systems in the *Cerrado* region, resulting from a wide technological diversity. Costa (1998), based on several authors, presented a review of some common characteristics of the beef prevailing systems in this region, as follows:

- Pastures and cattle. '*Nelore*' (*Bos indicus*) is by and large the main cattle breed. The average farm has 1,800 ha, mostly with cultivated pastures, particularly *Brachiaria* and *Panicum* grasses, under extensive systems. Continuous grazing, usually with no fertilisation, results in carrying capacities of 0.2 to 0.4 AU for native pastures and of 1 to 2 AU/ha for sown pastures. Additional pasture may be rented to overcome the dry season.

- Nutrition and other practices. Pasture-based systems prevail (95%) with mineral supplementation provided on a regular basis and urea, only occasionally, in the advent of severe droughts. Forage conservation and other supplementation practices are not common. Natural breeding is the main reproductive practice although artificial insemination is increasingly observed. Animal health practices include the vaccination against Foot and Mouth disease (FMD) and Brucellosis (only females), as well as anthelminthic treatment. Cattle are finished at four years of age and sold directly to abattoirs.

- Labour, management and capital. The majority of farmers live in town and have off-farm activities that provide an inflow of capital into the farm. They reinvest the farm profits and avoid borrowings. Farmers have a hired manager to make operational decisions and supervise workers. Costa (1998), citing Fernandes and Costa (1983), highlights that farmers are in charge of the strategic and tactical decisions but claims they usually have low managerial skills.

Although Costa's (1998) review is not recent, it provides a reference in time for comparative purposes. For instance, a comprehensive study using panel data was conducted in 2005 on the modal (most frequent) beef production systems in *Goiás* (GO) and *Mato Grosso do Sul* (MS)

States, both in the *Cerrado* region. A general description and some average performance indicators of the typical farms in GO and MS States are presented in Table 2.2.

Table 2.2 Description of prevailing beef systems under *Cerrado* conditions

State	GO	MS	MS
Micro - region	*Vale do Araguaia*	*Campo Grande*	*Dourados*
General description			
Climate Precipitation (mm) Temperature (°C)	 1,650 20 - 25	 1,470 19 - 24	 1,410 18 - 25
Total farm area (ha)	1,440	1,500	1,000
Area of sown pastures (ha)	1,152	1,200	800
Sown species	*B. brizantha* *B. humidicola* *A. gayanus*	*B. decumbens* *B. brizantha* *B. humidicola*	*B. decumbens* *B. brizantha* *B. humidicola* *P. maximum Tanzania*
Carrying capacity (AU/ha/year)	0.8	0.6	0.7
Grazing system	Continuous	Continuous	Continuous
Supplementation at the dry season[1]	M: Protein supplement F: Urea	-	-
Herd (AU)	922	719	560
Activities	Complete cycle	Complete cycle	Complete cycle
Buildings & Machinery (US$)[2]	221,891	238,348	207,486
Performance indicators			
Age at first calving (months)	37	44	38
Calving rate (%)	70	60	60
Death rate until weaning (%)	5	6	8
Male weight at weaning (kg)	160	150	155
Female weight at weaning (kg)	150	135	145
Age at slaughter (months)	40	45	45
Male weight at slaughter (kg)	495	490	470
Female weight at slaughter (kg)	345	390	360

[1] Mineral mix is provided on a regular basis in all regions; M: male and F: female.
[2] Based on local market prices in August, 2005; exchange rate 1US$ = 1.986 R$

Source: adapted by the author, based on Costa *et al.* (2005a) and Pereira *et al.* (2005a)

The overall beef system and farm descriptions are somewhat similar to prevailing beef system described by Costa (1998) for the *Cerrado* region as a whole. In general, the typical farms in GO and MS presented low productivity, with prevailing extensive systems as suggested by the systems' low carrying capacities. According to Costa *et al.* (2005a) and Pereira *et al.* (2005a), natural mating usually with no defined breeding season was common, with calving rates varying from 60% to 70%. None of the typical farms had technical support. Formal planning and record keeping were not common, except for tax purposes. However, advancements were also noticed. The use of more productive grass species in all farms, such as *Brachiaria brizantha* and *Panicum maximum*, and cattle supplementation on the farm in GO suggest improvements on cattle nutrition. The age at slaughter seemed to be reduced from 48 months, as suggested in Costa's (1998) review, to 40 to 45 months, maybe as a reflection of the better diets.

Although there are more advanced beef systems in the *Cerrado* region than those presented so far, there are fewer studies focusing on this type of farm, as discussed in Chapter 1. For instance, a search of online databases, including CAB, Pro-Quest, Web of Science, Science Direct and Google Scholar, using terms related to Brazilian beef farming as well as qualifiers such as progressive, entrepreneur, innovative, leaders and variants thereof retrieved no relevant result. This may be due to two hypotheses: (1) there may be a lack of interest in this group of farmers; and (2) there may be a misspecification of studies' main target group.

Innovative beef systems are relevant because farmers running such systems tend to be open to new ideas, and therefore, technologies. They are likely to play a relevant role in the social system, by importing and displaying technologies, and thereby reducing uncertainties of other farmers who may be encouraged to consider adoption. There is a lack of understanding of these farmers' motivations and the limitations characterising their beef systems.

2.5 Summary and Conclusions

In this chapter, the Brazilian beef industry has been described and the gaps highlighted. Figures showed the significant participation of Brazil as a major player in beef global markets. This participation is expected to become even more significant, given the Brazilian capacity to increase both beef production and productivity, responding accordingly to global increases in meat demand. In the domestic market, increased demand linked both to the population increase and the more equitable distribution of income has been observed and is likely to continue. However, weaknesses in the beef supply chain may limit the pace of the industry development. Technological and organisational heterogeneity and lack of coordination among the components of the beef supply chain have been remarkable. There is a high informality in the domestic beef sector, including illegal cattle slaughter. The technological heterogeneity and the informality in the Brazilian beef supply chain bring operational difficulties for effective sanitary control and full implementation of traceability systems.

This heterogeneity is not only observed for the processing sector, but also for the producing sector. In this chapter, it was shown that Brazilian beef farmers are spread throughout the country, facing different regional conditions. Often, these conditions create investment opportunities, justifying cattle migration among regions. The diversity of the regional conditions, including agro-ecological, social, economic, cultural and institutional aspects, leads to a diversity of beef farming systems. Under the *Cerrado* ecosystem, typical beef farmers have been characterised by extensive systems and low use of working capital, resulting in limited performance. Despite the presence of advanced farms, the lack of research on these farms has limited the understandings of their characteristics and prevailing systems.

Chapter 3
Decision Making Theories and Models

3.1 Introduction

The main body of literature on decision making (DM) processes is reviewed in this chapter, with particular emphasis on farming decisions. The review highlights the shift from piecemeal ideas on human rationality and behaviour towards a more holistic approach. This includes the evolution of theories and models, departing from a purely economic to an integrated socio-psychological approach. The review also consider a critique of such models to ensure the pitfalls and gaps are understood. Understanding DM theories, models and their underlying assumptions on how people make decisions is relevant for the context of this research that is concerned with technology adoption decisions. Particular attention is given to cognitively-based DM models that have been increasingly used in agricultural studies.

3.2 Decisions in a Farm Context

The literature on decision making (DM) within the farm context is voluminous and comprehensive, including the context for decisions, decisions under risk and uncertainty, the types and relevance of decisions, and the steps of decision making. Farmers around the world constantly face farming decisions including 'what' to produce, 'how much' to produce, at which technological level and cost. These decisions involve personal aspirations and experience, socio-cultural backgrounds, biological processes, economic factors, resources availability and constraints. The ability to make 'good' decisions, given all these aspects, has been acknowledged by several authors as a determinant of the farm success. Kadlec illustrates this idea by asserting that *"an important attribute of a successful manager is the ability to make decisions that will enable the business to attain its goals"* (Kadlec, 1985, p. 27).

It is not without challenges that decisions are made, however. According to Kay *et al.* (2008, pp. 30-31), agriculture entails a peculiar environment for decision makers as farms, and farming, have unique characteristics that are not comparable to other non-farming businesses. Firstly, farmers cannot accurately predict production due to climate and biological processes. Moreover, in many cases family and business are intertwined and there is a dynamic interaction between them, with a direct impact on farming goals. In contrast with non-farming businesses, it is common for farmers to operate in all levels of management, as they are owners and managers of the farms as well as providing labour. They argue that this situation poses pressure on farmers, who often place management into a secondary role. Also, it is not possible to fully replicate farming systems if a farmer decides to expand the business (i.e., by buying or renting more land), given the uniqueness of every farm, or piece of land. This means that for each farm, farmers may need to make decisions under quite different contexts. Finally, another important characteristic of agriculture is that most farmers operate in largely perfectly competitive markets, that is, they have little, if any, influence on input or output prices.

All of these challenges illustrate the risk and uncertainty involved in decision making within a farm context. Decisions under risk and uncertainty have been the topic of many research papers (Bacic, Bregt, & Rossiter, 2006; Engler-Palma, 2002; Isik & Khanna, 2003) and chapters of farm management textbooks (Harsh, Connor, & Schwab, 1981; Kadlec, 1985; Kay et al., 2008; Martin, 2005; Olson, 2003). There are several sources of risk in a farming context, including production, financial, legal, social, technological (Martin, 2005), market and personal risks (Kay et al., 2008). The relative importance attached to different sources of risk varies amongst different people. Understanding individual's perception of, and attitude, to risk seems, therefore, a necessary condition for the understanding of how farmers make decisions, including adoption decisions. This topic is covered in more detail in the next chapter.

Despite the risk and uncertainty involved in decision making, farmers are constantly making decisions. According to Kay *et al.* (2008), these decisions are either at strategic or tactical levels. At a strategic level, decisions have major impacts on the farm business as a whole since they focus on the long-term horizon. In contrast, decisions at tactical levels concentrate on medium to short term and are more limited in scope. The extent to which a decision impacts on the attainment of farming goals ultimately determines the relative importance of this decision. In general, strategic decisions are more important than other decisions.

Other criteria also influence the relative importance of decisions and have been reported by Castle *et al.* (1987), Kay *et al.* (2008) and others. These criteria are: frequency, imminence and revocability of decisions as well as the number of alternatives for choice. Frequency refers to how often a decision is made. In general, frequent decisions (e.g., feed cattle everyday) tend to become 'rules of thumb' while less frequent decisions require farmers to think through them more carefully. Imminence is also a determinant of the relevance of decisions because the 'cost' of delaying a decision is not the same for all types of decisions. Thus, decisions in which high penalties are involved are more relevant and should be made prior to other decisions. The ease of revoking the decision is another criterion for the decision analysis (i.e., revocability). Decisions that allow for flexibility are usually easier to make (and revoke) than decisions in which the cost of change is too high. Lastly, when farmers face a multitude of alternatives to choose from the decision is more difficult. In this case, they need to, somehow, bring the number of alternatives down to a manageable set in order to make a decision (Harsh *et al.*, 1981).

Not only the characteristics of farming decisions have been analysed by researchers, but also the process of decision making. Within the farm management field, the DM process has been approached by and large from a functional standpoint with the objective of showing farmers how they *should* make decisions if an optimum result is to be achieved (i.e., normative approach) (Castle et al., 1987; Harsh et al., 1981; Kay et al., 2008). Traditionally, the DM process has been described as a series of phases (and steps) that farmers *should* go through. A summary of the phases involved in decision making, with their respective steps, is presented in Figure 3.1.

Phase 1 (Assessment)	**Phase 2 (Making sense)**	**Phase 3 (Action)**	**Phase 4 (Analysis)**
Steps: Identify problem or opportunity Identify alternatives	*Steps:* Collect data about each alternative Analyse alternatives thoroughly	*Steps:* Make the decision Implement the decision	*Steps:* Evaluate outcome Bear responsibility

Figure 3.1 Phases of the decision making process

Sources: adapted from Castle *et al.* (1987), Harsh *et al.* (1981), Kadlec (1985) and Kay *et al.* (2008)

Despite variation on the details or terminology used by individual authors, in general the steps are taken in a sequential (i.e., linear) way. The decision process starts with an ‘assessment’ phase where problems, opportunities and possible alternatives are mapped out. This initial phase is followed by a ‘making sense’ phase when farmers gather data and use it to make sense of the *pros* and *cons* of each alternative. The ‘decision’ itself (i.e., choice of an alternative) follows and is a step within the ‘action’ phase. This phase also includes the step of implementing the decision. In the final phase, namely ‘analysis’, outcomes are evaluated and responsibility accepted.

This linear model of DM has been criticised, however. Ohlmer, Olson and Brehmer (1998) argue, and others agree (Nuthall, 2010; Olson, 2003), that farmers do not follow linear steps when making decisions. To support their argument, Ohlmer *et al.* (ibid) carried out 18 case studies of Swedish farmers, including two longitudinal studies that lasted three years. Results showed that farmers undertook a dynamic process of decision making which involved constant evaluation of the decision as new information arose. This new information influenced not only the current decision but also fed forward to new decisions as it impacted on farmers' future expectations and goals (i.e., learning process). This continuous reassessment of decision is in sharp contrast with the linear model, where evaluation occurs only at the end of the decision process (Figure 3.1). They proposed, therefore, a matrix model to better represent the dynamics of the decision making process instead of the linear step-by-step model. In their revised conceptual model, the decision process encompasses four phases and four sub-processes (Ohlmer *et al.*, 1998, p. 285), as shown in Table 3.1.

Table 3.1 Conceptual model of the decision making process

	Sub-processes			
Phase	Searching & Paying attention	Planning	Evaluating & Choosing	Bearing responsibility
Problem detection	Information scanning Paying attention		Consequence evaluation Problem?	Checking the choice
Problem definition	Information search Finding options		Consequence evaluation Choose options to study	Checking the choice
Analysis & Choice	Information search	Planning	Consequence evaluation Choice of option	Checking the choice
Implementation	Information search Clues to outcomes		Consequence evaluation Choice of corrective action	Bearing responsibility for final outcome Feed forward information

Source: Ohlmer *et al.* (1998)

This conceptual dynamic model represented advancement in knowledge regarding the process of decision making and, as highlighted by Nuthall (2010, p. 87), seems to be the *"logical way to operate"*. Despite this advancement, questions remained unanswered as to 'how' and 'why' farmers actually decide on particular courses of action. Both linear and dynamic models pay little attention to the *mental processes* of decision making; these mental processes provide information on 'how' and 'why' decisions are made. Instead, both linear and dynamic models essentially focus on the *functional processes* of decision making (i.e., from a managerial perspective). An evidence is that both models (Figure 3.1 and Table 3.1) include a step called 'make decision' (or choice) but neither expand on this. In this sense, these models lack an explanation of the farmers' cognitive processes that lead to particular choices. This explanation is provided by other models that are discussed later in this chapter.

Before discussing other models and theories on DM however, a discussion on 'rational decision making' may prove helpful given different assumptions on human rationality and behaviour underlie the diverse theoretical frameworks that exist.

3.3 Rational Decision Making and Its Critique

Decision making has been widely studied within several disciplines (e.g., economics, sociology and psychology) with application in an even wider range of fields, such as business administration, farm management, rural development and consumer behaviour amongst others. For each of these disciplines and fields, decision models reflect researchers' philosophical principles, which, in turn, influence the way the models have been developed and interpreted.

Within the farm management field, decision making has often been analysed under the traditional neo-classical economic theory that suggests that people make decisions in order to maximise 'utility' (or well-being). Given the 'ethereal' character of this construct, Edwards-Jones (2006) points out that economists often use 'profit' as a proxy of 'utility' because it allows for objective analysis[6]. Under this assumption, farmers, as rational entities, make decisions to maximise profits or minimise costs (Edwards-Jones, 2006; Featherstone, Moghnieh, & Goodwin, 1995). Agricultural economists have been using this approach to support decisions on the optimum levels of inputs, the least-cost animal feed (Harsh *et al.*, 1981) and for many other decision problems that exist. However, empirical studies have shown that farmers' behaviours often do not conform to the models. An illustrative example is the work by Featherstone *et al.* (1995), in which 289 farmers in Kansas were tested for optimisation behaviour under the hypotheses that they were profit maximisers and cost minimizers. The findings showed that farmers violated both optimisation hypotheses. These results raise the question of whether farmers are irrational or whether the theories are overlooking relevant aspects of decision making.

Many researchers agree with the latter explanation and, in response, have developed other theories of human rationality and motivations for behaviour. An example is the work of Gladwin (1989), which focused on understanding how and why people make decisions the way they do. It has been demonstrated that several factors in addition to economics play a

[6] Although Edwards-Jones (2006) acknowledges much advance in adoption research was due to the use of profit as a proxy of 'utility', this researcher also criticizes this assumption, arguing this is a simplistic view.

relevant role in decision making (Feder, Just, & Zilberman, 1985). For instance, social influences, networks and cultural values were found to influence decisions (Alencar, 1988). Additionally, farmers' various objectives, which are often conflicting, have been reported to impact the decision making process (Costa & Rehman, 2005; Fairweather & Keating, 1994; Gasson, 1973; Wallace & Moss, 2002). The objectives often change in the context of the farmers' life cycle stage, personality, experiences and farm characteristics. In terms of decisions, this means that priorities change over time and so does the process of decision making.

These findings revealed the complex and dynamic nature of the decision making process, challenging the neo-classical economic theory and its reductionist approach (i.e., merely economic). As a result, alternative views on human rationality have been developed, incorporating a more holistic approach to human nature. Within this holistic view, a farmer (or any person) is not seen solely as an individual economic agent, who acts exclusively to maximise his/her economic goals. Rather, s/he is part of a social system, influencing and being influenced by this system. Because of the interactions between the farmer and the social system, his/her decision settings change over time. For decision theories, the implication of this conceptual development is that other factors must be accounted for to acknowledge the complexity of decisions. Given the various assumptions on human rationality and behaviour, several theories and models on decision making arose. In the next sections, these main theories and models are reviewed.

3.4 Schools of Thought on Decision Making

There are several schools of thought on decision making. Hammond, McClelland and Mumpower (1980) described, and Sjah (2005) summarised, six general approaches to decision making. These included: decision theory (DT), behavioural decision theory (BDT), psychological decision theory (PDT), social judgement theory (SJT), information integration theory (IIT) and attribution theory (AT). According to Hammond *et al.* (ibid), the main supporting disciplines for these theories range from pure economics to pure psychology, as one moves from the decision theory towards attribution theory. The theories between these two extremes (i.e., DT and AT) spread in a continuum and integrate both disciplines to a greater or lesser extent according to how close they are to the economic or psychology end of this continuum. The economic-based theories are concerned with what people *should* do and their focus is on preferences, decisions and choices. Psychologically-oriented theories, in contrast, are concerned with why and what people *actually* do. They focus on knowing, perceiving and judging.

Theories that deal with 'knowing' are beyond the scope of this research, as they are concerned with how people build knowledge, drawing heavily on psychology to explain their premises. These theories are information integration theory (IIT) and attribution theory (AT), which according to Sjah (2005), have not been commonly applied in agricultural studies. The former emphasises the cognitive integration of multiple pieces of information and how this impacts on the stimulus-response relationship, whereas the latter deals with the psychology of common sense and the tension between common sense and scientific knowledge (Hammond *et al.*, 1980). The remaining theories (DT, BDT, PDT and SJT), or parts thereof, are relevant to this study to various degrees as it draws on diverse elements from these theories. For example, the aim of this study assembles the aims of BDT and PDT while the topic of DT, that is 'choice among alternatives with multiple attributes', is similarly considered here. A summary of these four decision making theories is presented in Table 3.2.

The summary below is not exhaustive as there are other theoretical frameworks of decision making that were not considered by Hammond *et al.* (1980). For instance, in their review, they built on the disciplines of economics and psychology to classify decision making theories, but there was no mention of sociology. Thomas (1955), in contrast, called attention to this very discipline and its influence on the decision making framework. He pointed out several ways in which sociology helps to explain the decision making process, including: influence on one's goals and objectives; propensity to seek gains or avoid losses; formulation of expectations on individuals', group or institutional behaviour bearing a decision; and social pressure in arriving at a particular decision. A study by Sambodo (2007) provided some empirical evidence for this claim. In the review carried out by Hammond *et al.* (ibid), however, sociological aspects were only implied by the aim of social judgement theory (SJT), that is, to understand the interaction between environmental cues (including the social environment) and cognition.

Table 3.2 General theories of decision making (DM)

DM Theory	*Disciplines**	*Type of analysis*	*Main topic*	*Assumptions*	*Theory aim*	*Typical approach(es)*
Decision theory	**Economics**	Mathematical and Probabilistic	Choice among alternatives with multiple attributes	People assign utilities and probabilities for different outcomes of alternatives and seek to maximise the expected utility (usually inferred from profit)	Support decision makers to achieve rational decisions, particularly in complex situations	Prescriptive: suggest what people should do, if they want to be in conformity with logic and rationality
Behavioural decision theory	**Economics** Psychology	Probabilistic	Description of less-than-optimal behaviour of decision makers	People assign utilities and probabilities for outcomes of alternatives but keep reviewing their estimates as new information becomes available	Understand **how** people depart from 'rational' decisions (behavioural analysis)	Descriptive: find cognitive aspects that impact on people's 'rationality' under uncertainty
Psychological decision theory	Economics Psychology	Psychological	Explanation of cognitive mechanisms, including memory, perception and experience, that people use to assign probabilities to particular outcomes	People have limited cognitive capacity to process information and behave less-than-optimally	Understand **why** people depart from 'rational' decisions (cognitive analysis)	Explanatory and predictive: explore the reasons for less-than-optimal behaviour and predict behaviour under particular circumstances
Social judgement theory	**Psychology** Economics	Socio-psychological	Observation of probabilistic behaviour of those making judgements and decisions (often include groups of decision makers)	People judge alternatives based on their perceptions. These are formed on the basis of environmental cues and influenced by experience	Understand the interaction between physical, biological and social environmental cues and cognitive systems, and how this affects judgement and decision making	Descriptive: describe human judgement processes and how perceptions are formed

* Disciplines in bold highlight the predominance of a discipline within a particular theory (e.g., Economics prevails in DT).

Source: based on Hammond *et al.* (1980)

Under the general guidelines of the foregoing theories on decision making and people's rationality, several specific models, theories and variants have been developed using econometric techniques or a descriptive approach. Some specific theories and models that have potential application to this research are reviewed next.

3.5 Econometric theories and models

3.5.1 Single and Multi-Equation Models

Single and multi-equation models have been largely used in adoption-decision studies, usually under the guidelines of 'decision theory' (Table 3.2). These models focus on providing explanations for, or predicting, behaviour. In the former case, the models are built to test hypotheses on causal relationships between dependent (i.e., adoption) and independent variables in order to identify and measure major factors facilitating or preventing adoption. In the case of prediction, models build on these factors to estimate the likelihood of a particular behaviour (i.e., adoption behaviour). Generally, the underlying assumption in these mathematical models (i.e., single and multi-equation) is that farmers' adoption behaviour is intended to maximise expected utility, subject to constraints such as land availability (Feder *et al.*, 1985).

Logit, probit (Feder *et al.*, 1985) and tobit approaches (Adesina & Zinnah, 1993; Garson, 2010; Sambodo, 2007) are examples of single equation models that have been frequently used in adoption research. Logit and probit models are derived from general linear models (using regression analysis) to better deal with categorical and dichotomous (e.g., adopt or not-adopt) dependent variables (Garson, 2010). The logit model uses a cumulative logistic function to determine the probability of a dependent variable assuming one of two outcomes (e.g., 1 or 0). In probit models, this probability is estimated by using a cumulative distribution function. Both models produce similar results, though. According to Garson (ibid), the tobit model was expanded from the probit model to address cases where dependent variables have high skewness and concentrate within a limited (i.e., censored) interval. This model yields the probabilities of adoption and the intensity of adoption (Adesina & Zinnah, 1993), with the advantage that the disaggregation of the model coefficients shows the effects of a change in one variable on changes in the probability of adoption, i.e., the marginal effect (Adesina & Baidu-Forson, 1995).

Logit, probit and tobit models use both primary and secondary data to analyse decisions *ex-post*. The dependent variable is usually treated as dichotomous (i.e., adopt or not adopt) while independent variables can be categorical (dichotomous or ordinal) or continuous (Garson, 2010). Studies using such models are usually concerned with aggregate adoption, which Jangu (1997) considers particularly useful for policy makers. Some applications of these models include: factors affecting adoption of sustainable agricultural practices in the United States using a logit model (D'Souza, Cyphers, & Phipps, 1993); determinants of the adoption of coffee pulping technology in Brazil using a logit model (Monte & Teixeira, 2006); the impact of gender on the adoption of agricultural innovations in Ghana using a probit model (Doss & Morris, 2001); rate and intensity of adoption of land-enhancing practices in Niger using a tobit model (Baidu-Forson, 1999); and, the effect of farmers' perceptions on new sorghum and rice varieties introduced in Burkina Faso and Guinea using a tobit model (Adesina & Baidu-Forson, 1995).

Despite acknowledging the appropriateness of logit and probit models for (actual) dichotomous variables, Feder *et al.* (1985, p. 283) question this dichotomy involving adoption. They argue that while most studies consider farmers as adopters or non-adopters, adoption of agricultural technologies is often incremental resulting in various levels of adoption. In their opinion, models should account for adoption intensity (i.e., for divisible technologies), which is not the case of logit and probit models.

Moreover, these single equation models are static and only capture the *status quo* of adoption of a given technology in a specific period in time (Sambodo, 2007) but do not address the dynamics involved in decision adoption processes (Feder *et al.*, 1985). Adoption rates change over time as a result of learning processes, since farmers constantly update their perceptions as new information arises (Feder *et al.*, 1985, p. 259). The work by Jangu (1997), who identified 'constrained' and the 'wait-and-see' types of non-adopters, provides some evidence for the dynamic nature of adoption: these non-adopter groups could become adopters if constraints were removed or if they learned more about an innovation respectively.

Multi-equation models, in contrast, may be used for sequential or dynamic decision making processes. In these models, emphasis is placed on explaining the interrelationship among variables in different equations (Austin *et al.*, 1998 cited in Sambodo, 2007), which may overcome some pitfalls of single equation models. A multi-equation model can be simply a series of single equation models, as demonstrated by Negatu and Parikh (1999). They used both a probit model and an ordered probit model to explore the relationship between farmers' perceptions on, and adoption of, agricultural technology in Ethiopia. Another example was Moser and Barrett's (2006) study of smallholder farmers in Madagascar: first, a dynamic probit model was used to analyse the trial of a technology; then a tobit model was developed to verify the intensity of adoption among farmers who tried a technology; and, finally, a probit model was employed to isolate factors influencing disadoption.

Alternatively, multi-equation models can also use a structural equation model (SEM) approach, which is a multivariate statistical model that combines regression analysis, factor analysis among other methods (Austin *et al.*, 1998 as cited in Sambodo, 2007). Hoyle (1995, p. 14) defends that SEM is the most comprehensive and flexible statistical approach to research design and data analysis used in social and behavioural studies. According to this author, the main advantage of SEM is that it is designed to test hypotheses about the relationships between observable and latent variables. Latent variables (i.e., non-observable) are of particular interest for social scientists because often they want to learn about the effect of people's perceptions, personality, motivations and other non-observable factors on behaviour. Alvarez and Nuthall (2006), for instance, used structural models to analyse the relationship between farmers' attributes, including personality, learning style and skills, and the adoption of computer-based information systems.

According to Gladwin (1989, p. 11), probit and logit models can be tested against choice data and be used alongside rule-based decision models (e.g., decision tree models) to evaluate the correlation of a particular decision criterion and the decision outcome. However, for researchers interested in the mental processes of decision-making, a major limitation of single and multi-equations models is their non-cognitive nature when it comes to the choice process (Gladwin, 1989, pp. 10-11). For this reason, these models seem inappropriate to address the aim of this research of gaining insights on farmers' cognitive process from an "emic" point of view. Other theories and models have addressed cognition in decision making, and are reviewed next.

3.5.2 Theory of Planned Behaviour (TPB)

Theory of planned behaviour is one special case of a multi-equation model that that attempts to portray people's cognition. According to Ajzen (2005, p. 117), this theory assumes that people behave in a sensible way, take into account available information and consider the results of their actions. The theory also postulates that *"a person's intention to perform (or not to perform) a behaviour is the most important immediate determinant of that action"* (Ajzen, 2005, p.117). Moreover, it acknowledges and incorporates other determinants of behaviour in the conceptual model to account for attitudes, social influences and perceptions over control. These determinants are named, respectively: attitude toward the behaviour, subjective norm and perceived behavioural control. Altogether, they impact to a greater or lesser extent on behaviour, depending on the circumstances under analysis. Therefore, the TPB provides a framework to explain the relationships between decision variables, including latent ones, and behaviour.

By means of structural equation modelling (SEM), TPB incorporates economic, socioeconomic, socio-cultural and psychological aspects in behavioural analysis (Burton, 2004). According to Ajzen (2005, pp.123-124), the model specification assumes that people assign probabilities of occurrence of each outcome associated with behaviour and whether these outcomes are positive or negative. How much they believe in such an association determines the 'belief strength'. An estimate of the attitude toward behaviour is obtained by summing the resulting products of 'belief strength' multiplied by the outcome valuation (i.e., $A = \Sigma\, b\, v$, where A is attitude, b represents the belief strength and v, the valuation of an outcome). This assumption implies that when the decision maker expects mostly positive outcomes, s/he develops a favourable attitude toward the behaviour; or an unfavourable attitude, otherwise. According to Feather (1982), as cited in Beedell and Rehman (2000, p. 119), the underlying principle assumes an expectancy-value form which is similar to the economists' expected utility model.

Within agricultural studies, the Theory of Planned Behaviour has been applied to research on farmers' technology adoption (Lynne, Casey, Hodges, & Rahmani, 1995; Sambodo, 2007), other issues of public interest, such as animal welfare (Austin *et al.*, 2005, as cited in Edwards-Jones, 2006) and conservation behaviour (Beedell & Rehman, 2000). However, a major emphasis on attitudes towards behaviour has resulted in some criticisms to TPB. Burton (2004), for instance, drew attention to this tendency of behavioural analysis focusing on attitudinal aspects at the cost of the other elements of the TPB model, i.e., the subjective norm and perceived behavioural control. According to Edwards-Jones (2006), the challenges involved in estimating these two elements of TPB explain the lack of emphasis on them. Beedell and Rehman (2000) also made some criticisms to TPB, such as: (1) the possibility of acquiescence biases since behavioural measures are estimated by the farmers themselves; and (2) the difficulty of interviewees to understand and cope with the TPB procedures, which follow a standardised method that is time consuming and monotonous.

Despite these criticisms, the TPB represents a great improvement on the efforts to incorporate socio-psychological aspects into behavioural studies. Also, the TPB allows for either 'etic' or 'emic' aspects to be included in the questionnaire. In the latter case, an exploratory study is required to elicit the 'emic' variables to researcher wants to introduce in the models. However, the application of TPB calls for large sample sizes given the numerous variables considered in this model. For this reason, TPB does not fit the strategy undertaken by this research, which is discussed in Chapter 5.

3.6 Descriptive theories and models

3.6.1 Theory of Real-Life Choice

The theory of real-life choice is concerned with how people do make decisions in real-world contexts. In contrast with other decision making theories (e.g., linear-additive or normative models), the theory of real-life choice maintains that people do not make decisions by holistically assigning utility and probabilities to each alternative and then ranking and selecting the option with the highest 'expected utility' (Kahneman & Tversky, 1972). Instead, the choice among multiple alternatives occurs by comparing alternatives on one dimension at a time and eliminating those with least desired characteristics on this dimension (Gladwin, 1989, p. 10). This process occurs in order to make decisions cognitively manageable and viable. According to Nuthall (2010), farmers simplify decision making to achieve efficiency by, for example, using intuition, experience and rules, amongst other strategies, to make decisions.

Studies have shown that in real life people prefer a simple approach to decisions rather than complex approaches (Gladwin, 1989; Jangu, 1993; Ohlmer *et al.*, 1998; Sjah, 2005), given the cost in time and mental energy (Nuthall, 2010, p. 87). What is more, people frequently use 'rules of thumbs' (i.e., heuristics) in trying to manage multiple alternatives and make decisions easier (Nuthall, 2010, p. 88; Sambodo, 2007). Given the limited access and cognitive capability for processing information, the best decision is the one within people's reach, given their current knowledge and constraints (Murray-Prior, 1998). Thus, it is realistic to assume that people generally make reasonably rational decisions with respect to their particular objectives, e.g., they have 'good' reasons to do what they do.

To assume that people make reasonably rational decisions implies that people themselves are experts on how (and why) they make their decisions. 'People as experts' is the main underlying assumption of the real-life theory (Gladwin, 1989, p. 9). Given this central role of decision makers for real-life choice theory, ethnographic[7] techniques have been applied to studies on decision making using such a theory as a framework. These techniques allow for

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[7] The dictionary definition of Ethnography is *"the study and systematic recording of human cultures [and] a descriptive work produced from such research" (Merriam-Webster, 2011)*. According to Gladwin (1989, p. 9), it is concerned with describing a culture from 'insider's' (e.g., interviewee) rather than 'outsider's' (e.g., interviewer) point of view. Ethnographic techniques rely heavily on fieldwork and participant observation to minimize researchers' own ethnocentricity, i.e., *"the viewing of another culture through the lens of one's own cultural values and assumptions"* (Gladwin, 1989, p. 9).

decision makers to reveal their own decision criteria and for researchers to develop cognitive-based models.

One particular model that uses ethnographic techniques and has become popular among some scholars is the Ethnographic Decision Tree Modelling (EDTM). Gladwin (1989, p. 9) asserts that this model is built from insider perspectives using 'emic' criteria (relevant for interviewees) rather than 'etic' criteria (imposed by researchers). In this sense, the model is not designed to test researchers' interpretation of what the decision criteria should be but to identify and describe criteria people use to make decisions. A consequence of this specification of the model is that it is highly context-sensitive, as different people in different environments may use different criteria to address similar issues. Given the EDTM cognitive-based nature and its modelling being grounded on 'emic' criteria, this method seem highly appropriate to the research approach undertaken here, as it is discussed in later chapters.

EDTM has been used to understand farmers' decision making for a variety of decisions in various countries. Examples of studies using EDTM include: farmers' tree planting behaviour (Fairweather, 1992) and conversion of traditional farming systems into organic production in New Zealand (Fairweather & Campbell, 1996); technology adoption among Mexican farmers (Gladwin, 1977 as cited in Gladwin, 1989); adoption of new sheep breeds (Jangu, 1993); adoption and non-adoption of heifer synchronisation among dairy farmers in New Zealand (Jangu, 1997); adoption of paddy-prawn system among Indonesian semi-commercial farmers (Sambodo, 2007); and, access and repayment of agricultural credit in Indonesia (Sjah, 2005). In Brazil, the only application of a decision tree model was found in Santos (2005). In this study, though, the decision tree is used as a framework to simulate the viability of supplementary irrigation for sugarcane producers in the State of 'Alagoas', Brazil. The model was built in a prescriptive fashion to indicate the conditions in which the viability of supplementary irrigation systems is higher and, consequently, when farmers *should* adopt such a technology.

Despite the benefits of using ethnographic decision tree modelling, the model has its pitfalls. One pitfall is that the model building is time consuming (Murray-Prior, 1998) and challenging as there are only general guidelines on how to build the model. This lack of formal procedures of model building is illustrated by Gladwin's (1989, p. 40) comments: *"you juggle decision criteria 'by the seat of your pants' and see if the tree you get makes sense and predicts well enough"*. Although this may suggest models are arbitrary, they are developed based on real world decisions eliciting criteria that are a cue of people's mental process. Moreover, model testing allows for further confirmation of decision criteria and their ordering.

Researchers' generalisation of 'emic' criteria is another challenge with this method. Such generalisation is often necessary in order to merge several individuals' 'emic' criteria into one general quasi-'etic' criterion that makes sense in the model. During this process, some minor decision criteria may also be disregarded in the final composite model. The challenge, therefore, is to preserve the ethnographic validity of individual models, that is, informants have to 'go down' the composite model through the same path and end up with the same outcome as they did before. Usually, model testing minimises researcher's bias (e.g., mis-specification of criteria) and ensures internal validity.

A major limitation of EDTM is that the model does not provide a psychological explanation for the choice of decision criteria (Fairweather & Campbell, 1996; Jangu, 1997; Murray-Prior, 1998; Sjah, 2005). In other words, EDTM does not provide explanations as to why informants choose a particular set of criteria to guide their decision making process. This explanation is only possible by further assessment of informants, which can be done using the Personal Construct Theory - PCT (Murray-Prior, 1998), among other theories. PCT is reviewed next.

3.6.2 Personal Construct Theory (PCT)

George Kelly, an American psychologist, developed a comprehensive theory of personality based on the assumption that ordinary people, when trying to understand the world they live in, are much like scientists (Boeree, 2006). Boeree (ibid) summarises Kelly's (1955) theory:

> *Ordinary people [...] have constructions of their reality, like scientists have theories; they have anticipations or expectations, like scientists have hypotheses; they engage in behaviours that test those expectations, like scientists do experiments; and they improve their understandings of reality on the bases of their experiences, like scientists adjust their theories to fit the facts (Boeree, 2006, p. 5).*

From this observation comes Kelly's theory, whose philosophical base was called *"constructive alternativism"* (Boeree, 2006, p. 3). This philosophy suggests that while there is only one true reality, reality is experienced from different perspectives or alternative constructions. This implies that there are many different ways of making sense of the same reality and, as Kelly claims, in order to better understand behaviour one has to understand how people construe reality. Kelly's theory, namely Personal Construct Theory (PCT), is therefore concerned with how people construe themselves, other people and their world. This is potentially relevant to technology adoption studies because the way farmers construe their farming systems and technologies, in particular, is likely to impact their adoption behaviour.

According to Kelly (1955), in the construction of reality, each person uses models, hypotheses or representations that s/he has made about her/his world. These models consist of cause-effect rules people have developed and constantly reassess and improve when anticipating future events. In doing this, people create structures of meaning, known as personal construct systems, on which one's mental processes run. Constructs carry two relevant meanings: they represent how people have constructed their past experience and also their predisposition to perceive (or construe) the future. For instance, if a person considers technologies with the construct cheap-expensive, s/he has experienced at least one cheap and one expensive technology. Also, if a particular technology is perceived as expensive it is likely that this perception will remain in the future unless an additional effort is made to change this opinion.

PCT is organised into one fundamental postulate and 11 corollaries, which together, explain the ways people construe events in the environment (Kelly, 1955). The fundamental postulate establishes that:

> *A person's processes are psychologically channelized by the ways in which he anticipate events (Kelly, 1955, p. 46).*

According to Boeree (2006), the interpretation of this postulate shows that people's experiences, thoughts, feelings and behaviours are determined not only by the reality out there but also by people's efforts to anticipate the world, other people and their own self. Murray-Prior (1998) reiterates, saying that people's expectations of the future and how their behaviour will impact future events direct their motivations, thoughts and consequently behaviours. Thus, beliefs, values, actions and ways of thinking are determined by the constructs rather than by outside motivation (Kelly, 1955).

An extension of the main postulate led Kelly to develop 11 corollaries. These corollaries are reproduced in Boeree (2006, pp. 6-12) and reported below. A brief explanation on each corollary is provided based on Kelly's original work (1955) and Boeree's (2006) summary.

- Construction corollary: *"A person anticipates events by construing their replications."* This corollary suggests that people expect events to happen as they happened before. Therefore, people construct their anticipation of the future based on their past experiences.

- Individuality corollary: *"Persons differ from each other in their construction of events"*. Since people have different experiences, their construction of reality differs from one another.

▪ Organisation corollary: *"Each person characteristically evolves, for his convenience in anticipating events, a construction system embracing ordinal relationships between constructs"*. Some constructs are connected to each other, being subordinate to others in taxonomic ways (e.g., plant-animal ⇔ reptile-mammal ⇔ four legs-no legs), in some cases. Other constructs are independent (e.g., biological-artificial construct and dark-bright construct). Some constructs are construed tightly while some are loose. An example is preconceptions about people: if one construes stereotypes of people tightly, s/he may not see people other than stereotypically (e.g., people carrying all the constructs associated to the stereotype), whereas the same constructs construed in a loose manner will result in the observer remaining open-minded to different constructions of people.

▪ Dichotomy corollary: *"A person's construction system is composed of a finite number of dichotomous constructs"*. This corollary suggests that constructs have a bipolar nature, which allows people to make sense of the world regarding similarities and contrasts among events (e.g., easy-difficult; good-bad etc). There are several peripheral constructs but people use mostly a more limited number of core constructs, that is, those that are most important to them and, to some extent, define who they are.

▪ Choice corollary: *"A person chooses for himself that alternative in a dichotomized construct through which he anticipates the greater possibility for extension and definition of his system".* This proposition highlights that people make choices of alternatives that enhance their prediction ability. In other words, people choose the alternative that they anticipate will most likely elaborate their construction system (i.e., improve their ability to anticipate).

▪ Range corollary: *"A construct is convenient for the anticipation of a finite range of events only"*. Kelly says that no construct is useful for all events. Some constructs are very comprehensive (e.g., good-bad) while others are narrower (e.g., male-female). Each construct, therefore, has its own range of convenience and applicability.

▪ Experience corollary: *"A person's construction system varies as he successively construes the replication of events".* This means that people learn from experience and adapt their construction system (reconstruction) when new events happen with unexpected outcomes. In this sense, this corollary supports the ideas involved in Bayesian[8] learning.

- Modulation corollary: *"The variation in a person's construction system is limited by the permeability of the constructs within whose range of convenience the variants lie".* This corollary introduces the permeability of constructs, that is, how open the construct is to include new events which are not yet construed within the current framework. In other words, if a person's superordinate constructs are impermeable, s/he will construe very little when confronted to new events.

- Fragmentation corollary: *"A person may successfully employ a variety of construction subsystems which are inferentially incompatible with each other".* This corollary admits that people can be inconsistent within themselves, depending on the circumstances. Boeree justifies this corollary by explaining that a person plays different roles in life (e.g., one individual may be woman, wife, mother, daughter, worker etc.) and, therefore, may use different (and often inconsistent) constructs for each situation.

- Commonality corollary: *"To the extent that one person employs a construction of experience which is similar to that employed by another, his psychological processes are similar to the other person".* This means that people sometimes share analogous construction systems and thus they have a similar understanding of reality. People from the same culture, for instance, are likely to share views and see the world similarly.

- Sociality corollary: *"To the extent that one person construes the construction processes of another, he may play a role in a social process involving the other person".* This corollary means that one can put oneself aside and 'live in someone's shoes' and, in doing so, relate to, and construe, other people's constructions. In this way, it is possible to understand other people, establish effective communication and, therefore, play a relevant role in these people's lives.

Because the postulate and the corollaries represent the psychological basis for behaviour, the personal construct theory (PCT) has been increasingly used in agricultural studies that aim at improving their understandings of farmers' behaviour (Jangu, 1997; Sambodo, 2007; Sjah, 2005). One particular field of interest has been farmers' technology adoption (and sometimes, non-adoption) behaviour. Jangu's (1997) work is an example of application of PCT in

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[8] According to Ghadim and Pannell (1999, pp. 150-151), based on Anderson *et al.* (1977), "*Bayes' theorem allows us to revise probabilities based on new information and to determine the probability that a particular effect was due to a particular cause*". For example, a farmer with a perceived distribution of the profitability of a beef technology engages in a trial to narrow the gap between his/her perception and the actual profitability.

agricultural settings. Jangu (ibid) analysed Canterbury dairy farmers' constructs for heifer synchronisation and reported that adopters and non-adopters construed this innovation differently. While most adopters associated heifer synchronisation with the construct 'genetic gain', non-adopters had various other constructs related to this technology. This explained the existence of three groups of non-adopters, named by Jangu as: "discontinued", "wait-and-see" and "would never adopt". Among farmers who never adopted the technology, the 'would never adopt' farmers had impermeable constructs since they were not open to consider adoption. The 'wait-and see' farmers, in contrast, were still considering the *pros* and *cons* of the innovation, suggesting they had permeable (loose) constructs.

Despite claims that PCT can be used complementarily to EDTM, one can argue that, to a large extent, decision criteria and constructs are similar. The elicitation of decision criteria in real-life decision theory assembles the procedures recommended by the Personal Construct Theory. For instance, while Gladwin (1989) suggests decision criteria must be elicited by comparing and contrasting behaviours, the PCT requires interviewees to compare and contrast three elements to find the two alike and the third contrasting in terms of a particular aspect (or construct). Sjah (2005, pp. 67-68) provides further details with this regard.

Consequently, theoretical insights from both PCT and EDTM can be useful to elicit farmers' constructs for different types of innovations, which is one of the objectives of this thesis.

3.7 Summary and Conclusions

It was shown in this chapter that decision theories in the farming environment are of various types, have diverse impacts on farm performance and involve different factors. In an attempt to understand the decision making process and support decision makers, several theories and models have been developed. Some models were concerned with the functional perspective of decision making and described the steps managers (e.g., farmers) should take in order to achieve their goals (e.g., linear and dynamic models). Other models focused on the process of choice among alternatives or motivations for behaviour. The assumptions behind these models vary, however.

It was shown how changes in the understanding of human rationale, as reflected in the theories and models underpinning decisions, have moved from a purely economic approach to a more comprehensive one. The different assumptions on human rationality have given rise to different schools of thought, which have influenced behavioural research in general, and decision making research in particular. The disciplines of economics, sociology and psychology have served as a framework to these schools of thought to a greater or lesser extent. Additionally, the theories expanded their scope from being normative or prescriptive, i.e., telling people what they *should* do, to include theories on *how* and *why* people behave the way *they do* (i.e., descriptive and explanatory research). As a result, models incorporated socio-psychological factors into behavioural studies.

Some theories and models that are potentially useful for this research on technology adoption behaviour were reviewed. These models are: single and multi-equation models; theory of planned behaviour (TPB); theory of real-life choice and the personal constructs theory (PCT). Single and multi-equation models are often not cognitively-based and seem not to be appropriate for the purposes of this research. Moreover, these models have been used for aggregate adoption behaviour and have little to offer when it comes to explaining individual farmers' adoption-decisions. The theory of planned behaviour, despite considering cognition to some extent, is usually designed from an 'etic' standpoint. Moreover, its requirement for large sample sizes makes TPB unsuitable to this case study with farmers.

In contrast, the theory of real-life choice was suitable to the objectives of this research, as the theory is genuinely concerned with understanding people from an 'inside' perspective. The real-life choice theory, and its ethnographic decision tree modelling (EDTM), allows farmers to 'have a voice' on the issue under investigation (i.e., technology adoption), as they are assumed to be the 'experts' on their own decisions. The assumption that people compare alternatives based on one dimension at a time seems reasonable and so does the assumption of hierarchical decision process, with an 'elimination-by-aspect' followed by a 'hard-core' phase of DM. Despite the challenges involved in building the tree models and the criticism on the lack of psychological explanation for behaviour, EDTM seems to be a suitable method for exploratory studies like this.

The psychological explanation lacking in the EDTM can be addressed in the personal construct theory (PCT), which was also discussed in this chapter. PCT is another compelling theory in terms of the potential benefits for this study from the insights it provides. PCT's main assumption of 'man as a scientist' complements and supports the assumption of the man as an 'expert' in EDTM. Elements of PCT may prove helpful in understanding farmers' technology adoption decisions, particularly regarding different types of technologies. Therefore, PCT along with the theory of real-life choice will serve as theoretical frameworks for this research. Details of the analytical approach to these theories will be discussed in the methods chapter (Chapter 5).

The theoretical discussion carried out in this chapter provided the principles underlying decision making studies. In the next chapter, the focus of the discussion shifts to technology adoption decision, which is a specific case of decision making. Empirical studies are reported and discussed in order to bring to light the factors that have been considered influential to farmers' technology adoption and non-adoption behaviour.

Chapter 4
Factors Influencing Farmers' Technology Adoption Decisions

4.1 Introduction

In the previous chapter, decision making theories and models were presented and their applications in a farm context discussed. In this chapter, the discussion narrows to concentrate on farmers' technology adoption decisions and the factors influencing these decisions. The main aim of this literature review is to report what scholars have done and found worldwide in the field of technology adoption decisions while highlighting the gaps that may exist.

In an ever-changing world, a farmer constantly considers the adoption of new technology. These adoption decisions have been of particular interest given their spill-over effects beyond the farm gate (Feder *et al.*, 1985; Feder & Umali, 1993), and their impacts on agricultural development (Edwards-Jones, 2006). As a result, a considerable number of studies have been carried out with particular emphasis on the factors that influence, or more specifically constrain, technology adoption decisions.

Typically, these studies have considered factors such as farmers' social-psychological and socioeconomic characteristics, their social milieu, farm conditions (e.g., natural resources and climate) and technologies attributes. Also, the literature describes the influence of external forces to the farming systems (e.g., policies, market and R&D) that impact on adoption decisions. Some of these external forces (R&D and Brazilian beef market) have been discussed in Chapters 1 and 2; all the remaining factors will be discussed next. At the end of Chapter 4, a brief summary is presented.

4.2 Farmers' Socio-Psychological Characteristics

There has been a substantial increase, particularly over the last two decades, in the body of adoption literature focusing on farmers' socio-psychological characteristics. Studies include the analysis of farmers' goals (Costa & Rehman, 1999; Fairweather & Keating, 1994; Gasson, 1973), management styles (Fairweather & Keating, 1994) and ability (Nuthall, 2001), attitudes (Beedell & Rehman, 2000), perceptions (Sall, Norman, & Featherstone, 2000), learning processes (Wake, Kiker, & Hildebrand, 1988), intra-household communication (Sambodo, 2007; Warriner & Moul, 1992) and social network (Oreszczyn, Lane, & Carr, 2010; Warriner & Moul, 1992). These and other related factors are discussed in more detail below.

4.2.1 Farmers' values, objectives and goals

Farmers' values, objectives and goals play a relevant role in adoption decision making as they set the limits for 'rational' behaviour (i.e., behaviour that is faithful to one's own value system). According to Nuthall (2010, p. 164), values form the basis for establishing the boundaries for people's behaviour, as they set limits of what is relevant (and often socially acceptable) in life. Additionally, Gasson (1973, pp. 524-525) argues that values are culturally constructed and less likely to change with time or circumstance than goals, imposing some regularity on behaviour. Some examples of values are honesty, humanity, integrity, freedom and independence. Objectives, in turn, are established within people's value sets and become operational by the setting of specific goals, as Nuthall (2010) describes. For example, a farmer whose objective is to expand his farm business may set himself the goal of buying an additional 500 ha in the next five years. Despite the distinction between objectives and goals, these terms have been used interchangeably as in many studies 'goals' are referred to as general statements (like objectives). This is illustrated by the examples of goals cited in Gasson (1973, p. 524) and in Fairweather and Keating (1994). Here, these terms are also used interchangeably.

As discussed in Section 3.2 (Chapter 3), the neoclassical economic theory assumes a farmer's objective is to maximise 'utility'; but given its ethereal character, 'utility' is often measured in terms of profits, albeit imperfectly (Edwards-Jones, 2006). Therefore, in many agricultural studies a profit maximising farmer has been assumed. However, as Edwards-Jones (2006, p. 784) noted, real-world situations do not always confirm such an assumption, as farmers may make different decisions when facing similar situations. For instance, the study by Featherstone *et al.* (1995) (presented in detail in Chapter 3, Section 3.2) provided some evidence of farmers' violation of this maximisation assumption.

This view of a profit Maximiser farmer has been criticised by scholars who are concerned with real-world decisions (Gasson, 1973; Gladwin, 1989). They propound that people are unlikely to have the single objective of maximising profit (i.e., economic objective) but a mix of economic and non-economic objectives (Gasson, 1973, p. 522). For example, Gasson (ibid) listed, from a series of empirical studies, several values and goals that farmers held. Among the non-economic objectives relevant to farmers were: lifestyle, social, spiritual and family-related objectives. Gasson (ibid) found that the feeling of satisfaction was more often associated with the achievement of non-economic than economic goals. Another example of the importance of non-economic goals was evident in a case study conducted by Ohlmer *et al.* (1998) with 18 Swedish farmers. They found that farmers' highest valued goals were to remain on the farm and hand over an improved farm for the next generation. Goals related to private consumption, leisure time and risk taking were also highly valued.

Under the assumption of multiple objectives, Gasson (1973) points out farmers seek to attain several goals simultaneously and often have to prioritise and trade-off goals (e.g., labour-intensive technology may decrease time spent with family). The prioritisation of goals is unique to individual farmers and is determined by the interactions between personal and environmental factors that change over time. In other words, the changing circumstances of an individual impact on the 'utility' s/he gets from particular events (Edwards-Jones, 2006, p. 783), for example the adoption of a new technology. This, in turn, influences how this individual prioritises the events associated with his/her goals, with direct impact on the balance between economic and non-economic ones. Moreover, in achieving such a balance individuals are likely to 'satisfice' rather than maximise solutions, given their limited cognitive capacity to gather and process information and the unreliable nature of human memory (Simon, 1957).

Historically, the study of farmers' goals and values started with the premise of better understanding farmers' motivations for farming and providing researchers with insights on major farming orientations. A reference paper is that of Gasson (1973, p. 527), whose literature review pointed to a non-exhaustive list of four farming orientations: (1) instrumental, in which farming is a means of income and security; (2) social, for whom the farm gives opportunity to thrive on interpersonal relationship and community values; (3) expressive, in which farming is seen as a means of self-expression and personal fulfilment; and (4) intrinsic, that is, farming activities and environment are enjoyed for their own sake.

Other studies, building on Gasson's (1973) pioneer work, also contributed to this emerging body of literature. For instance, Fairweather and Keating (1994) and Brodt, Klonsky and Tourte (2006) identified various management styles defined according to the prevailing sets of goals held by New Zealander and American farmers respectively. A common assumption underlying such studies is that gaining insights on farmers' goals and values enables the understanding, and sometimes the prediction, of their behaviour (e.g., technology or policy adoption). In a different fashion, Darnhofer, Schneerberger and Freyer (2005) modelled Austrian farmers' decisions on whether to convert to an organic farming system. Based upon their decisions, the researchers drew conclusions on these farmers' farming orientations and, indirectly, on their prevailing sets of goals.

A gap remains in the literature, however, as to whether these sets of predominant goals in fact determine behaviour and, if so, how this process occurs and to which extent. Unlike the study by Darnhofer *et al.* (2005), in which farmers' actual behaviour was modelled, most studies on farmers' goals are limited to the identification of goals. Nevertheless, overlooking the gap between what farmers claim (i.e., intentions) and what they actually do may result in misleading conclusions since constraints may prevent their actions.

4.2.2 Managerial ability

According to Nuthall (2010, p. 15), farmers' managerial ability relates to many attributes including taking and accepting responsibility for decisions made to achieve farming objectives. Whether farmers can make good decisions depends on their personal attributes and experience. These attributes involve farmers' personality, motivation, intelligence and learning style. Therefore, to understand farmers' technology adoption decision it is necessary to consider the underlying attributes of managerial ability. These are reviewed below, based principally on the work by Nuthall (2001, 2010) since he provides a comprehensive review of all these attributes and their application to the farm management field, particularly to what he calls *"decision ability"* (Nuthall, 2001, p. 248). Moreover, the study of managerial ability is an emerging field within the adoption literature and some of its attributes have not been extensively analysed in the agricultural context.

Personality is one attribute of managerial ability that may impact farmers' adoption decision, given that it has been shown (Willock *et al.*, 1999) that personality influences behaviour. According to McCrae and Costa Jr. (1997, p. 509), many psychologists are convinced that personality traits are best represented by the five factor model (FFM). This model maintains that human personality encompasses five major traits: openness, conscientiousness, extroversion, agreeableness and neuroticism. People exhibit a unique combination of all the five traits to a greater or lesser extent. Although there is no ideal combination of traits (i.e., personality type), Nuthall (2010) suggests that a successful farm manager is open to new ideas (openness), takes responsibilities seriously (conscientiousness), interacts easily with other people (extroversion), is usually good-natured and calm (agreeableness) and is resilient (controls anxiety). However, he also acknowledges that in particular circumstances a good manager is required to act in the opposite direction (e.g., being assertive and firm rather than soft and agreeable).

According to Ajzen (2005), personality traits are latent characteristics of individuals and, as such, can only be inferred by observable cues, behaviour being the most important. In addition to observation, which can be costly and time consuming, Nuthall (2010, p. 47) sets up a test based on FFM to assess farmers' personality traits within a farming context. The combination to various extents of the five personality traits identified in the test defines a farmer's management style.

This management style, based on farmers' personality, resembles the management styles deriving from farmers' values and goals (discussed in Section 4.2.1). Some of the statements in Nuthall's (2010) test relate to farmers' values and goals, and are similar to those found in Fairweather and Keating (1994). The opposite is also true in that some values and goals in Fairweather and Keating's (ibid) study may be cues to farmers' personality. This overlap between personality traits and values or goals suggests these factors are intertwined, as the former is likely to influence the latter two. Willock *et al.* (1999) demonstrated this relationship between farmers' objectives (and attitudes) and the five traits of personality. Moreover, their study showed these factors were also associated with farming behaviour. The extent of influence of farmers' personality traits, attitudes and objectives on their actual farming behaviour is yet to be analysed, according to the authors.

Motivation is another attribute of interest for adoption decision studies. According to McClelland (1987, p. 5), the three major personal factors causing a behaviour (for example an adoption behaviour) are motivations, skills (ability) and cognition (understanding of a situation). There is a debate among scholars, however, whether motivation is an attribute in itself or an expression of personality. Kline (1993), cited in Nuthall (2001, p. 249), argues there are no clear boundaries distinguishing personality from motivation, and urges more research in this field. In contrast, Davis and Newstrom (2002) and McClelland (ibid) assert that motivation is a need, a desire or an interest as opposed to a characteristic or a trait. For them, motivation not only propels an individual in a particular direction but also makes him/her persist in the chosen direction.

Despite the several theories on motivation, in general theorists agree that there are two sources of motivation: intrinsic and extrinsic motivation (Davis & Newstrom, 2002). Decy and Ryan (1985) explain that intrinsic motivation stems from individuals' inner force or desire to achieve their objectives and fulfil their value system. As such, intrinsic motivation is usually accompanied by emotions such as deep interest, excitement and enjoyment. This type of motivation is particularly important for human development, including learning, adaptation and competency development. Extrinsic motivation, in contrast, is stimulated by external factors which work as rewards or pressure for behaviour, as Deci and Ryan (1985, p. 35) point out. Both sources of motivation are important in explaining behaviour.

Within an agricultural context, an illustration of farmers' intrinsic and extrinsic motivations for undertaking conservation practices is provided by Greiner, Patterson and Miller's study (2009). They found that farmers pursuing lifestyle and conservation objectives were intrinsically motivated to adopt conservation practices because this enabled them to fulfil their value system; farmers primarily focused on financial/economic or social objectives seemed to be mainly driven by extrinsic motivations, such as government incentives or society recognition, respectively. These results suggest farmers' motivation influences their adoption behaviour, and by implication, the decision resulting in such behaviour.

One model that illustrates how motivation triggers the decision making process and influences behaviour, such as technology adoption, is proposed by Chiavenato (1983), the so-called motivational cycle. Assuming an initial state of 'equilibrium' on a farm, the motivational cycle is triggered by a stimulus (intrinsic or extrinsic stimulus), for instance, the establishment of a traceability system for beef exporters (i.e., extrinsic motivation). This stimulus results in a temporary discomfort (i.e., tension) to beef suppliers, who need to make a decision whether to cope with the new regulation or bear the consequences of rejecting it; a rejection of the traceability system will automatically preclude them from exporting beef. Thus, a careful analysis of alternatives takes place and a decision is made in order to relieve the tension and return to an equilibrium state. During the decision making process, barriers may stop them from doing what they want (for example financial constraints). In this case, the decision is straightforward (i.e., elimination by aspect, discussed in Chapter 3) and they do not implement the traceability system. Whether they are satisfied with this decision will determine whether the equilibrium is re-established (if they are satisfied) or the search for other alternatives will proceed (e.g., to get external funds to implement the system). On the other hand, if they decide to implement the traceability system, satisfaction is achieved once the implementation is completed and the equilibrium is again established. However, the traceability system may bring challenges and problems (i.e., stimuli) into the production system, and the motivational cycle may restarts.

Besides personality and motivation, another important attribute to farmers' managerial ability is intelligence. McGregor *et al.* (1996), for instance, found that gross farm income per hectare was correlated with farmers' IQ. Although there are several definitions and interpretations of what intelligence is, Sternberg and Salter (1982) comment cognitive theorists relate intelligence to information processing. They propose that intelligence reflects one's ability to learn from experience and adapt to ever-changing environment. In a farm context, this refers to farmers' capabilities of observing the cues, processing and interpreting information, making decisions and learning from the outcomes of such decisions.

Nuthall (2010, p. 31) summarises the main aspects of intelligence related to farmers' decisions, as follows.

- Memory: This is important in storing learned lessons from past experiences and information in order to solve problems in the future.
- Ability to improve constructs: With experience, farmers' construct system (discussed in Chapter 3) becomes better informed, improving their ability to make proper decisions. Improved constructs stored in the long-term memory result in better intuition, with positive impact on decision making.
- Creativity: Finding (innovative) new solutions is as important to farmers as learning from past experience. Creativity and imagination are, thus, relevant aspects of farmers' intelligence.
- Logical and mathematical ability: At least a basic level of this ability is required to solve farming problems.
- Visual-spatial ability: This refers to the ability of visualising objects and quickly making sense of what is happening and what needs to be done (e.g., walk on a paddock and estimate the available dry matter, just by looking at grass conditions).

A relevant part of 'farming intelligence' is farmers' learning processes, which allow for the improvement of their managerial abilities. Specifically, learning is important because it allows for skill improvements, uncertainty reduction (as one's proficiency increases) and better decision making (Marra, Pannell, & Ghadim, 2003). Wake, Kiker and Hildebrand's (1988), for example, observed that farmers trying new crop varieties had losses in the first year of implementation but increasing profits in the subsequent years. They concluded this result was due to farmers learning on how to handle the crops.

The learning process varies among farmers, with some learning by seeing (visual), hearing (auditory), doing (kinaesthetic) or reading and writing (text processing) (Nuthall, 2010, p. 42). The extent to which these preferences combine altogether defines farmers' overall learning style, which are described by Wake *et al.* (1988, p. 184) as: informational, observational and experiential. The informational learning consists of the use of secondary sources (printed material, for instance) to get information, i.e., about a new technology. Farmers using this type of learning learn mainly by hearing (auditory) and text processing. The observational learning, in turn, involves primarily learning by observing (visual). Finally, farmers who prefer to learn from their own experience have a predominant experiential learning style (kinaesthetic and, possibly, visual). These farmers are likely to run small tests with technology (i.e., divisible technology) before wide implementation. These three learning styles are most usefully seen as complements.

The learning process of individual farmers about a new technology can be represented by a curve with three stages. Dimara and Skuras (2003) suggest there are two learning stages preceding technology adoption, involving: (1) awareness, which consists of acquiring information on the new technology; and, (2) evaluation, that involves the use of the acquired information to assess the potential impact of adoption on a farmer's economic activity. Additionally, Wake *et al.* (1988) propose a third stage called "learning by experience", which implies an adoption decision had already been made. During this stage, learning results from full or partial adoption, as farmers become more proficient with the new technology over time.

The three stages of a learning curve overlap Rogers' (2003) model of innovation-decision process as it starts with a knowledge stage (equals to the awareness stage of learning), follows on with a 'persuasion' stage (equals the evaluation stage of learning) until an adoption decision is made and implemented. Similarly to the concept of "learning by doing" (third stage of learning) proposed by Wake *et al.* (1988), Rogers (ibid) suggests a confirmation stage, when farmers learn about the innovation through experiencing it and review their former expectations on the innovation outcomes. A comparison between Rogers' model of the innovation-decision process and the stages in a learning curve suggests that both are intimately related to the learning methods as proposed by Wake *et al.* (1988). During the awareness stage of the learning curve (or knowledge and persuasion stages of Rogers' model) farmers are likely to learn about a technology mainly using informational and observational types of learning whereas after adoption (or some extent of it) the experiential learning type prevails. Consequently, learning methods used by farmers are likely to be not only chosen on the basis of their preferential learning style, but may also be determined by the stage of the innovation-decision process (or of the learning curve) these farmers are at.

This discussion on farmers' learning processes suggests that farmers' learning style as well as the stage on the learning curve they find themselves in, call for particular channels of innovation communication. As Nuthall (2010) notes, the suitability of information delivery to farmers' learning styles determines how well farmers absorb information during the learning process. Therefore, there is a clear interface between farmers' learning, adoption processes and extension services. The latter should account for the former two.

In addition to the four attributes making up the farmers' managerial ability (personality, motivation, intelligence and learning style) discussed previously, Nuthall (2010) also considers farmers' attitudes to risk. This attribute is discussed in the next section (along with beliefs and perceptions) because it belongs to the general domain of attitudes.

4.2.3 Beliefs, attitudes and perceptions

According to Beedell and Rehman (2000, p. 119) beliefs are formed on the basis of the type of information an individual is exposed to, his/her experience and implied knowledge. Irrespective of being 'right' or 'wrong', beliefs shape behaviour. Different beliefs lead to different attitudes towards objects and behaviours. Attitudes are positive or negative, depending on the attributes of the object (or behaviour) and how these attributes fit in one's belief system. Perception is also important in behavioural studies because, among other things, it incorporates individual's beliefs on his/her ability to perform a behaviour, as suggested by the Theory of Planned Behaviour (TPB) (Ajzen, 2005), discussed in Chapter 3. Beliefs, attitudes and perceptions are, therefore, interconnected facets of human cognition, influencing people's willingness to engage in behaviours, including technology adoption. Some empirical evidence of such an influence on technology adoption has been reported in the literature.

Farmers' belief was the central focus of the work by Flett *et al.*(2004). They explored farmers' beliefs giving rise to attitudes, rather than the attitudes themselves, using the Technology Acceptance Model - TAM (for methodological details, see Flett *et al.*, 2004 p. 200). This model proposes that technology acceptance and usage is determined by two key beliefs (attitudinal components): perceived usefulness (PU) and perceived ease of use (PEOU). Analysing these beliefs amongst dairy farmers in New Zealand, Flett *et al.* (ibid) found that farmers' beliefs regarding the usefulness and ease of use of technologies discriminated adopters from non-adopters; perceived usefulness being more important than perceived ease of use.

Farmers' attitudes have been widely reported within agricultural contexts. Studies span farmers' attitudes towards particular technologies (Alvarez, 2002; Bigras-Poulin *et al.*, 1985; Flett *et al.*, 2004; Rehman *et al.*, 2007), policies (Defrancesco, Gatto, Runge, & Trestini, 2008) and, in particular, risk (Bacic *et al.*, 2006; Engler-Palma, 2002; Isik & Khanna, 2003; Marra *et al.*, 2003). Additionally, increasing environmental concerns worldwide have resulted in an expansion of the body of literature on farmers' conservation attitudes. Some examples are the studies by Baidu-Forson (1999). Beedell and Rehman (2000) and Greiner *et al.*(2009).

In general, these attitudinal studies found that farmers' positive or negative assessment of technologies (or policies) determine, among other factors, their predisposition to take-up these technologies. For instance, Rehman *et al.* (2007) noticed that attitudes of English dairy farmers towards three production technologies played a role in behaviour intent, which reflected in their actual adoption behaviour. More importantly, the findings revealed that farmers' beliefs originating their attitudes towards these technologies did not always conform researchers' beliefs on the merit of the technologies. This result illustrates the importance of understanding farmers' perspectives on adoption in order to develop and promote technology among farmers.

In line with other attitudinal research, studies on environment conservation and agri-environmental practices also have shown that, in general, farmers' positive attitude to environmental-related issues positively impacts adoption of conservation practices, or reduces the use of environment-damaging technologies. McGinty *et al.* (2008) found this positive relationship studying Brazilian farmers' adoption of agroforestry systems. Likewise, Beedell and Rehman (2000) reported that environmentally aware farmers were less concerned with farm management issues and were more into conservation-related ones.

A particular area of interest for attitudinal research has been farmers' attitudes to risk. As discussed in Chapter 3, risk is inherent to farm decisions as farmers do not have complete control of, or information about, the outcomes (and associated probabilities) of a decision (Olson, 2003, pp. 411-412). Given risk is unavoidable (Olson, 2003), it has been considered an important barrier for technology adoption (Feder & Umali, 1993), calling scholars' attention. In a review of empirical studies on the role of risk in technology adoption, Marra *et al.* (2003, pp. 219-222) report that attitudes to risk, risk preferences and the perception of the relative riskiness of enterprises impact adoption decisions. For instance, Marra *et al.* (ibid) cite, among other studies, the work from Ghadim (2000), who conducted a 3-year study with Australian crop producers comparing actual and planned adoption behaviour and the factors influencing any gap between the two. Ghadim (ibid) found strong evidence showing that risk aversion reduced technology adoption, particularly in situations where perceptions of relative riskiness and scale of operation were increased. In contrast, risk takers have been found to be more open to technology adoption. Greiner *et al.* (2009) analysed the influence of risk attitudes to the adoption of conservation practices among graziers also in Australia. Results showed that the attitudes of these farmers, self rated as risk takers, not only impacted significantly the number of conservation practices they carried out, but more importantly affected the type of practices they adopted.

Technology adoption has also been analysed considering farmers' perceptions. Studies have mainly focused on the perceptions farmers hold on certain characteristics associated with technologies and on how these perceptions influence adoption of new technologies. Some examples include farmers' perceptions of the characteristics of sorghum and rice varieties in Burkina Faso and Senegal (Adesina & Baidu-Forson, 1995; Adesina & Zinnah, 1993; Sall *et al.*, 2000) and improved wheat variety in Ethiopia (Negatu & Parikh, 1999), weed associated problems and control methods in Nigeria (Emechebe *et al.*, 2004) and fire use for pasture management in Central Brazil (Mistry, 1998). In general, all these studies found significant relationships between perceptions and adoption, with positive outcomes predominantly (but not exclusively) resulting from positive perceptions on relevant attributes of technologies and vice-versa. Adesina and Baidu-Forson (1995, p. 7) draw attention to the fact that farmers, as consumers of agricultural technologies, have preference for particular attributes of technologies; farmers' perceptions about these attributes particularly affect their adoption decisions.

In addition, studies have attempted to identify factors influencing the formation of perceptions, including the effect of adoption of a technology on these perceptions. The work by Negatu and Parikh (1999) illustrates this: they found a reciprocal interaction of adoption and perception of technology characteristics. Adoption affected perceptions, indicating that farmers' experience with a new technology feeds backwards into their perceptions.

In summary, the review of the literature presented in this section indicated that farmers' beliefs, attitudes and perceptions are influential aspects in adoption decisions. Although these aspects may not be sufficient to explain all of the variance in behaviour, they inform farmers' intentions towards a particular behaviour: positive beliefs, attitudes and perceptions usually lead to a favourable predisposition for adoption whereas negative feelings reduce the chances of voluntary adoption. Feather and Amacher (1994) argue that in order to increase technology uptake it is necessary to understand perceptions working as barriers and promote information dissemination and education to allow farmers to change negative beliefs, attitudes and perceptions.

4.2.4 The social milieu

The composition of farmers' social milieu has also been regarded as influential on adoption decisions (Edwards-Jones, 2006). The importance of the social context in farmers' adoption decisions is twofold: (1) farmers may feel the pressure of social actors to behave in particular ways (e.g., cultural settings) (Ajzen, 2005); (2) farmers learn about new technologies from interacting with other social actors, the so-called social learning (Conley & Udry, 2001). As Oreszczyn, Lane and Carr (2010, p. 415) argue, farmers' learning about new technologies happens in a complex social learning system. Despite largely relying on their own resources and experiences, farmers also interact with a large number of people, including both their peers and others in agricultural support organisations. Oreszczyn *et al.* (2010, p. 410) call this the *"web of influencers"*. Oreszczyn *et al.* (ibid), mapped this 'web of influencers' of potential adopters of genetically-modified (GM) crops in United Kingdom (UK), reporting several actors, both at individual and organisation levels. At an individual level, influencers included: accountant, agronomist, employees, family members, researchers, bank manager, farming neighbours and business advisors. Among organisation influencers were several government departments, research institutes, farmers' groups, supermarkets, discussion groups, farming press, seed companies and non-government organisations (NGO's).

Another example of farmers' 'web of influencers' is found in Solano, León, Pérez and Herrero (2003), who analysed the importance of 'significant others' as information and opinion sources to dairy farmers in Costa Rica. The importance of 'significant others' was determined across the four stages of the decision-making process. Results showed that in the 'problem detection' stage (first stage), technical advisors (TA) and family members (FM) were preferred among several possible information and opinion sources. Some preference was noted for farm staff (FS) in this stage. Within the 'seeking for problem solutions' (second stage), the relative importance of TA increased, while that of FM decreased, although both remained the most important information sources in this stage. This pattern repeated for the third stage of decision making ('seeking for new practices') with the main difference being the increase of the relative importance of commercial agents (CA). Finally, in the 'seeking for opinion' stage (fourth stage) FM and TA were again the main opinion sources.

The two studies above illustrate that farmers' web of influencers is wide and encompasses various actors. It also shows that the relative importance of influencers varies throughout the decision making process (Solano *et al.*, 2003), and, as pointed out by Solano, León, Pérez and Herrero (2001), among types of decisions and individual farmers. The specific mechanism in which farmers' 'web of influencers' operates and impacts on adoption decisions may be provided by the Theory of Planned Behaviour (TPB), particularly regarding its 'subjective norm' component (discussed in Chapter 3). Assuming that people in general seek for empathy and have a need for belonging, farmers' behaviours can be somewhat justified by their beliefs regarding the subjective norm (Ajzen, 2005). This means that their assessment on how their intended behaviour conforms to social norms or meets others' expectations influences their final adoption decision. Sambodo's (2007) study provides an illustration of such a mechanism, using TPB with semi-commercial farmers in Indonesia. Sambodo (ibid) found that farmers participating in a diffusion programme of paddy-prawn practice ('pandu') believed 'others' had expectations about their decisions on whether or not to adopt 'pandu' and that they needed to meet such an expectations. These 'others' included village leaders, extension practitioners disseminating 'pandu' and family members. Moreover, the social influence, particularly of farmers' family and neighbours, was also noticed in resource allocations. Often, practices carried out on neighbours' farms limited a farmer's alternatives (e.g., use of pesticide by a neighbour threats 'pandu' should the water get contaminated). Thus, a bargaining process involving both family and non-family members was significant in explaining these Indonesian farmers' actual adoption behaviour (Sambodo, 2007, p. 193).

The extent to which family members, other farmers, scientists, extension practitioners and other social groups influence technological adoption, i.e., social pressure, has called the attention of several scholars (Oreszczyn *et al.*, 2010; Solano *et al.*, 2001, 2003; Warriner & Moul, 1992). Solano *et al.* (2001) investigated the most basic research question in this regard: 'Who makes farming decisions?' They studied the actors involved in various farming decisions, including adoption decisions, in Costa Rica and found that while half of the decisions were made by the farmer solely, the other half was shared by, or delegated to, other actors, particularly family members. They also realised that the relative importance of 'others' in decision making was closely related to the type of decision: operational decisions were more likely to be delegated to staff and family members (who work on the farm), whereas technical decisions were mostly shared with technical advisors and family members. The relationship between the type of decisions and the influence of 'important others' was also investigated by Cezar (1999) in a study of Brazilian beef cattle farmers. Cezar (ibid) found that family members, consultants and other farmers were moderately relevant in strategic decision making (i.e., long-term impact). Tactical and operational decisions were monopolised by the farmer himself, with those social actors having little importance.

Warriner and Moul (1992), interested in the specific influence of family members on adoption decisions, analysed the effect of farm ownership (single owner, husband and wife or family holding) on the type of tillage adoption among Canadian farmers. They found nearly 60% of single owners used conventional tillage while family holding resulted in higher adoption of the conservation tillage practice (various extents, though). Despite the statistical difference suggesting that another family member on the farm encouraged adoption, the strength of this association was not strong, and adoption remained explained mostly by the traditional factors (farmers' age, education etc.).

There is enough evidence supporting the view that technology adoption decision is subject to social influence, as discussed above. Therefore, it is necessary to consider the social system farmers find themselves in to understand adoption decisions holistically.

4.3 Farm and Farmer's Characteristics

Most adoption studies mention farm and farmers' characteristics impacting on technology adoption (comprehensive reviews include Edwards-Jones, 2006; Feder *et al.*, 1985; Feder & Umali, 1993). Farmers' characteristics usually include age, gender, education and off-farm work. The stage in the family cycle and the level of on-farm pluriactivity are also considered, as pointed out by Edwards-Jones (2006). Among farm characteristics are the farm size, its biophysical aspects and land tenure.

Some studies have attempted to measure the association or the effect of a particular variable (e.g., gender) on the adoption of technologies (Doss & Morris, 2001; Helfand & Levine, 2004; Ward, Vestal, Doye, & Lalman, 2008) whereas other studies have drawn on multiple variables to explain adoption (Baidu-Forson, 1999; Boz & Akbay, 2005; D'Souza *et al.*, 1993; De Souza Filho *et al.*, 1999; Musaba, 2010; Rahelizatovo & Gillespie, 2004; Ward *et al.*, 2008). However, according to Feder *et al.* (1985) and Sall *et al.* (2000), results showing the influence of farm and farmers' characteristics on technology adoption have been mixed. This mixed effect is well illustrated in the work of Ward *et al.* (2008) on the adoption of 17 recommended practices among 729 cow-calf producers in Oklahoma, United States. They found the level of income dependence on cattle, human capital and size of operation, measured by the herd size, were statistically significant in explaining the overall adoption of the 17 technologies. However, the adoption models for each technology showed in some cases these variables increased the likelihood of adoption, whereas in others they decreased the likelihood, and yet in other cases, there was no statistically significant effect. Herd size, for instance, was statistically significant in five out of the 17 adoption models, affecting adoption positively. Thus, the larger the herd the more likely the adoption of these five technologies. For the remaining technologies, the effect of herd size was statistically non-significant. Education and age, which made up the human capital variable, were also statistically non-significant for the adoption of 14 and 11 technologies, respectively. On the other hand, education was positively associated with the adoption of three of the 17 technologies while the farmers' age was positively associated with the adoption of only one technology and negatively associated with the adoption of another five.

The same mixed pattern is found in the wider body of literature, involving studies in both developed and developing countries, in single or multiple technologies with a focus on a particular, or multiple, explanatory variables. For example, farm size was significant in explaining, and positively correlated with, the adoption of organic systems of currant production in Greece (Dimara & Skuras, 2003), improved wheat in Ethiopia (Negatu & Parikh, 1999), maize in Turkey (Boz & Akbay, 2005) and rice-wheat in Pakistan (Sheikh, Rehman, & Yates, 2003). In contrast, Pereira, Vale and Mâncio's (2005b) results suggested farm size was negatively related to the adoption of human resources management practices among Brazilian beef cattle farmers. The adoption of sustainable practices among Brazilian farmers in Espírito Santo State similarly decreased with the farm size (De Souza Filho *et al.*, 1999). Likewise, Kaliba, Featherstone and Norman (1997) found an inverse relationship between farm size in Tanzania and the adoption of stall-feeding management for improved dairy cattle and other related technologies (technological package). Several other studies, however, found no statistical significance between farm size and technology adoption (Gillespie, Kim, & Paudel, 2007; Matuschke, Misha, & Qaim, 2007; Ramirez & Shultz, 2000; Sall *et al.*, 2000).

For Kaliba *et al.* (1997, p. 145), farm size may be a proxy of farmers' wealth and, as such, relates directly to their investment capacity to adopt new technology. This explained the higher adoption of stall-feeding management among small dairy producers in Tanzania relative to large farmers: the latter were wealthy and had access to other, more suitable technologies. Moreover, Helfand and Levine (2004) noted that farm size may have an indirect influence on adoption as large farms generally have access to rural electricity, technical assistance and markets, which, in turn, facilitate adoption. The farm size may also relate to issues of production scale, labour organisation and farmers' prevailing objectives with impact on the suitability and subsequent adoption of technologies.

Land tenure is another relevant, but disputed, factor in technology adoption studies, particularly in developing countries (Ramirez & Shultz, 2000). The effect of land tenure on technology adoption varies due to the profitability and riskiness associated with the new technology (Feder *et al.*, 1985, p. 265). This explains why conservation practices are less likely to be adopted by renters of farmland than by landowners (Feder & Umali, 1993, p. 227). Some evidence is found in Gillespie *et al.* (2007, p. 97), who noted that land ownership increased the adoption of three erosion control practices and decreased the use of pesticide management among American cattle producers. Helfand and Levine (2004) may provide some additional explanation to these results as they observed that renters, particularly of large areas, are highly market oriented (as opposed to conservationists). Ramirez and Shultz's (2000) corroborate these results as they showed land ownership positively affected the adoption of agroforestry among farmers in Panama, and of the rational use of pesticides on tomatoes (integrated pest control technology) in Costa Rica. However, they also found no significant effect of land tenure on the adoption of another integrated pest control technology among this group of Costa Rican farmers. This result suggests that the effect of tenancy also varies with particular technologies. Moreover, the uncertainties involved in the lease contract may also influence farmers' adoption behaviour. Myyrä, Pietola and Yli-Halla (2007) ran a series of simulation models and found that investments in phosphorus fertilisation and lime application decreased over increasing uncertainty of contracts (complete certainty with land ownership to total uncertainty of the lease contract). They concluded the uncertainty over the continuation of the lease contract leads tenants to decrease adoption of irreversible land improvement practices.

The other farm characteristic often mentioned in adoption studies are the farm bio-physical and climatic conditions. Feder and Umali (1993, p. 227) report that in general, the literature shows that farm soil type, topography, water access and rainfall patterns influence farmers' beliefs around technology compatibility and usefulness. Sturm and Smith (1993) noted that one of the reasons Bolivian farmers did not try alternative crops, other than coca, was their perception that plants would not grow as well in experimental stations given the differences in soils. In Ethiopia, another study showed the proportion of vertisol soil type significantly increased farmers' perception of the grain yield of a wheat variety, which, in turn, effected adoption (Negatu & Parikh, 1999). Also in Ethiopia, sandy soil types and low water holding capacity were found to positively affect the uptake of short season sorghum, but to decrease the adoption of inorganic fertiliser (Wubeneh & Sanders, 2006). Gillespie *et al.* (2007) found that beef cattle producers in Louisiana with a stream and/or hilly (or river bottom) land were more likely to adopt erosion and sediment control practices than those without. All these examples demonstrate that particular technologies are suitable to some farms but not to others, highlighting the importance of understanding the regional (locale) context to explain adoption behaviour.

In addition to bio-physical characteristics, farmers' characteristics have also been associated with the adoption (and non-adoption) of technologies. In general, it is held that a male, young, well educated farmer with high income, most of it from farming, is more likely to adopt technologies than his counterparts. The rationale behind this stereotype is provided by Doss and Morris (2001, p. 27), who claimed that female farmers tend to adopt new technologies at a lower rate than male farmers. According to Feder *et al.* (1985) young farmers are usually more open to try new technologies because they are less risk averse than older farmers. The level of education also influences adoption because it is a known determinant of farmers' ability to understand and manage technologies (Doss & Morris, 2001, p. 36). Farmers' wealth has been often associated with technology adoption because wealthy farmers, in Doss and Morris' opinion (2001, p. 35), can better bear risks which facilitates the adoption of new technologies.

The work by Gillespie *et al.* (2007) illustrates this 'stereotype', showing that these attributes of farmers (except age) increased the likelihood of adoption of several best management practices. Ward *et al.* (2008) also found a positive and significant association between age, education and income from beef farming, and adoption. Similarly, Dimara and Skuras (2003) reported that conversion of currant production from conventional into organic systems in Greece was negatively impacted by age and positively influenced by years of schooling. These results also reinforced the 'stereotype' mentioned above.

However, the literature shows there are several exceptions to this stereotype, indicating this is an oversimplification of reality. An example is the study by Sall *et al.* (2000) with an improved rice variety in Senegal, which revealed that adoption was more likely among older farmers than among younger farmers, given the former's large experience with rice cultivation. Other studies found no significant impact of age on technology adoption (Doss & Morris, 2001) while others found a non-linear relationship, that is, adoption increases at first with age until a point where it has a detrimental effect on adoption rates (Ramirez & Shultz, 2000).

Gender is also a disputed characteristic when it comes to adoption. Studies have generally overlooked gender as an explanatory variable of technology adoption. This may be partially due to cultural differences among countries, with some where the gender issue is more pronounced than others. An illustration is provided by a comparison between maize producers in Ghana and Brazil. While in Ghana it is usual for both women and men (from different households) to manage their own maize plantation as a major part of their livelihood strategies (Doss & Morris, 2001), in Brazil maize production is by far a commercial activity (Garcia, Mattoso, Duarte, & Cruz, 2006) carried out mainly by men. This situation may be extrapolated to other agricultural produce since the Brazilian Agricultural Census showed men responded for 87.3 percent of the Brazilian farms (IBGE, 2006). For beef farming, a similar scenario is found as some empirical studies showed men were the main decision-makers in 89% of beef cattle farms in *Mato Grosso do Sul* State, Brazil (Cezar, 1999; Costa, 1998). According to Cezar (ibid), women were the main decision-makers when they were single, divorced or widowed.

In studies that did account for the effect of gender-related issues the results were mixed. Shadbolt (2005, as cited in Cullen, Warner, Jonsson, & Wratten, 2008) reported that female viticulturalists in a wine producing region of New Zealand were twice as likely to use pest biological control. Doss and Morris (2001), in turn, found that gender *per se* had no significant effect on the adoption of improved maize and fertiliser in Ghana. Their findings suggested, however, that the inequality of the levels of education, access to land ownership and to extension services between genders affected adoption accordingly. In Brazil, where both male and female farmers generally have similar levels of education, this inequality may be unimportant. The Brazilian agricultural census in 2006 (IBGE, 2006) reported around 54 percent of male and female farmers had at least primary education. Among secondary and tertiary educated farmers, females represented ten percent against nine percent of males.

Finally, farmers' off-farm work is another characteristic that can impact on technology adoption. According to Fernandez-Cornejo (2007), the importance of off-farm work for farming practices is twofold: it affects the farmer's income dependence on farming; and it changes a farmer's preference towards time-saving technologies (as opposed to managerially intensive technology). Gillespie *et al.* (2007) similarly assert that producers with low income dependence from beef farming are less likely to implement labour and management intensive 'Best Management Practices'. A study carried out by the Economic Research Service of the United States Department of Agriculture (USDA), reported in Fernandez-Cornejo (2007), showed that an increase in farmers' off-farm income increased the adoption of 'HT soybeans' and conservation tillage (both labour management saving practices) while it decreased the adoption of yield monitors, which is time consuming. Since there is a trade-off between time spent on on-farm and off-farm activities, and thus, a shift in technological preferences, the off-farm work phenomenon is worth further investigations.

The variability of results discussed above suggests that technology adoption is context sensitive, as particular characteristics of farms and farmers may be relevant in explaining adoption of certain technologies but unimportant to others. Thus, the multiple sources of influence on adoption need to be investigated under different contexts or regions. These sources of influence involve not only farm and farmers' characteristics but also the characteristics of the technology itself. Together, all of these factors determine the suitability and usefulness of a new technology. The technology characteristics will be reviewed in the next section.

4.4 Technology Characteristics

Farmers' perceptions on technology characteristics lead to positive or negative attitudes towards the innovation (as discussed in Section 4.2.3) and these attitudes affect farmers' willingness to adopt technologies (Adesina & Zinnah, 1993). According to Rogers (2003, p. 222), there are five general characteristics associated with technologies that explain about 50 percent of the variance in technology adoption rates. These characteristics are: (1) relative advantage; (2) compatibility; (3) complexity; (4) trialability; and (5) observability. The remaining variance is explained by other factors, such as those discussed throughout this chapter.

The technology characteristic 'relative advantage' is the degree to which a new technology is perceived as superior to the current technology (Rogers, 2003, p. 229). According to Batz, Peters and Janssen (1999), farmers will adopt an innovation if they perceive the new technology exceeds the 'utility' of the traditional technology. As he claims, this utility is determined by the nature of the technology, farmers' personal characteristics (e.g., goals), the farming system and the farming environment. Thus, the specific aspects of the relative advantage (e.g., profit, risk, social status, environment impact etc.) depend on the utility curve. In general, the greater the perceptions of relative advantage the higher the chances of adoption (Rogers, 2003). Flett *et al.* (2004), comparing adopters and non-adopters of four technologies for dairy farms, found that the perceived usefulness of technologies was higher for adopters than non-adopters. Perceived usefulness, in this case, may be seen as a proxy for relative advantage because this variable was made up of five dimensions, four of which were associated with technology relative advantage, that is, the technology: (1) is better than the one being replaced; (2) provides an increase in financial profit (i.e., compared to previous technology); (3) provides increased production; and (4) enables time saving. Flett *et al.* (ibid) found significant positive effect between the farmers' perceived usefulness of the technology and its adoption.

However, this relative advantage is not always clear to potential adopters, particularly in cases where the technology benefits are delayed, or the outcome of adoption is the avoidance of an undesired future event (Rogers, 2003, p. 234). In the former case, the time gap between adoption and the outcomes brings uncertainty to farmers, with some of them delaying (until they become less uncertain), or discarding adoption. For example, Fairweather (1992) noted that one reason mentioned by farmers for not planting trees was the gap between decision (and investment), and returns. When technology adoption results in the prevention of an unwanted event (preventive technology), perception of relative advantage is difficult as the 'outcome' is the absence of a possible effect. For instance, deworming may avoid a weight loss in cattle which is difficult for farmers to measure or estimate.

The innovation compatibility is another relevant characteristic. Perceptions on technology compatibility are construed on the basis of the technology's consistency to the individual's value system, past experience and current needs (Rogers, 2003, p. 240). Technology that is perceived as incompatible is unlikely to be adopted. Gillespie *et al.* (2007) provide some evidence to support this argument. They found the non-adoption of Best Management Practices among American beef producers was due to the belief that some of these practices did not apply to their farms, even though researchers believed the practices did apply.

The more compatible a new technology is to the old technology, the easier it is to be adopted (Wake *et al.*, 1988) due to familiarity. This may introduce, however, the misuse of a technology as farmers may repeat old and sometimes unsuitable practices (Rogers, 2003, p. 244), resulting in less-than-expected performance, and, possibly, discontinuation of adoption. Finally, an innovation's compatibility to farmers' needs is crucial to achieve efficacy. There is little point in developing the right technology to the wrong problem.

To a lesser extent, the complexity of an innovation is also important for the adoption behaviour because the difficulty in understanding and managing a new technology may affect farmers' willingness to adopt it (Rogers, 2003, p. 257; Batz *et al.*, 1999). As Flett *et al.* (2004) demonstrated, farmers not using a technology consistently find it more difficult to understand and use than adopters. However, they noted this may be caused by a systematic bias since those who are using the technology may have re-appraised their initial perceptions (i.e., before adoption) on the 'ease of use'. According to Batz *et al.* (1999, p. 125), the more complex the technology is in relation to the traditional technology, the lower are the adoption rate and the ceiling of adoption. Wake *et al.* (1988, p. 187) argue technology complexity impacts on farmers' perception of the cost of learning, and also on the belief of their learn abilities, which may explain the propositions of Batz *et al.* (ibid). In general, the complexity is more of an issue for innovators and early adopters of an innovation than it is for other farmers, who benefit from the experiences and knowledge of the pioneers at lower costs (Wake *et al.*, 1988, pp. 188-189).

The trialling of a technology is another important characteristic as it allows farmers to develop skills (Ghadim & Pannell, 1999) and, at the same time, assess the performance of an innovation, reducing uncertainties around its adoption. Specifically, Ghadim and Pannell (ibid) claim that farmers review their expectations on profitability (i.e., in a Bayesian fashion) as they 'learn-by-doing' during the trial period. The possibility of trialling a technology in a small scale increases the rate of adoption, particularly among innovators and early adopters (Rogers, 2003). However, for non-divisible technology this possibility does not apply. In this case, on-farm observation of the non-divisible technology (i.e., at research centres or other farms) may be more important for farmers.

Finally, observability is the degree to which an innovation and its results are visible (Rogers, 2003, p. 258). The general rule is that the more visible the results, the more rapid the rate of adoption. Nonetheless, technology is often composed of hardware and software, with the latter not often observable (Rogers, 2003, p. 259). Thus, technology with prevailing software components is usually adopted at slower rates as it possesses less observability.

4.5 Government Policies and Market Conditions

In this section, the focus turns to external factors (i.e., those where farmers have little, if any, control) affecting technology adoption, such as market conditions and government policies, including agricultural and credit policies, among others. These external factors provide the general investment environment for farming decisions, including adoption.

Government policies play a role in farming systems by developing farming regulations, supportive policies (e.g., subsidies) and providing the macro-economic environment, all of which affect farmers' decision-making. Whether policies are perceived by farmers as positive or negative depends on the focus of the policy. The compulsory characteristic of regulations sets boundaries to farming systems, and thus limits farmers' decision-making. The uptake of voluntary agricultural policies, in contrast, depends on farmers' perceptions of the advantages and disadvantages of joining the scheme (Defrancesco *et al.*, 2008).

Agri-environmental policies illustrate this case; these are governmental policies that promote, often through financial incentives, the conservation or sustainable use of natural resources (Edwards-Jones, 2006, p. 785). Defrancesco *et al.* (2008) identified that non-participating farms in agri-environmental schemes in Italy were labour intensive, highly reliant on income from farming, had high investments and a market orientation. In contrast, participating farmers had a positive attitude towards environmental protection. This attitude was particularly influenced by the opinions of society, in general, or neighbours, in particular (social influence). A study with Canadian farmers found that successful outcomes occurred because by joining environmental schemes these farmers could: publicise farm stewardship practices, improve relationships with non-farming neighbours and comply with government environmental regulations (Atari, Yiridoe, Smale, & Duinker, 2009).

The above results suggest the incompatibilities of the policies with farmers' values or farming conditions, as well as uncertainties around the impact of such policies to the household income, were important factors limiting the uptake. In contrast, the farmers' personal motivations and values, coupled with the role of their 'web of influencers' seem to be factors contributing to the uptake of voluntary policies. These factors must be accounted for to improve the efficiency of policy design and implementation.

Agricultural credit, which is another governmental policy, seems to impact on farmers' adoption decisions although to various degrees. Nyaribo and Young (1992) ran an *ex-ante* analysis of the impact of a credit programme on adoption of a dual-purpose goat in Kenya. They found the effect of credit, even in a highly subsidised scenario was low for small farmers given their main constraint was land, and not capital. However, medium and larger farmers strongly benefited. According to Sjah (2005, pp. 31-32), drawing on several authors, agricultural credit programmes allowed an overall increase in technology adoption and agricultural production in countries such as Taiwan, India and Botswana. Sjah reports that credit programmes can also aim primarily at farmers' income as happened in Bangladesh, Bolivia, India, Indonesia, Kenya, Malawi, and Sri Lanka. In this case, it has little effect on technology adoption.

Other government policies that influence technology adoption, discussed in Lee (2005), include: exchange rate policies (affects relative prices of exports and imports); domestic agricultural policies, including subsidies (both within a country and abroad); labour market policies; investment in public rural education and infra-structure, such as transportation, electricity, communication and access to markets; rights to land and water; and, investment in research and extension. The influence of these policies on adoption, however, occurs at a macro level, i.e., setting the overall environment for the farming businesses. Consequently, the impact of these policies on the adoption of particular technologies may be difficult, and somewhat, arbitrary.

Finally, market conditions are also an external factor farmers have to deal with in making decisions. Input and output prices, consumers' demands, processing sector requirements, infra-structure available for production flow, competitors intra and inter countries are some examples of market aspects that farmers face (Guerin & Guerin, 1994). The extent to which these factors affect technology adoption at an individual level depends on farmers' objectives, socio-economic conditions, psychological traits, and overall perceptions and expectations regarding market conditions. All of these aspects have been the subject of analysis throughout this entire section, and thus, require no further discussion.

4.6 Summary and Conclusions

In this chapter, a thorough analysis of factors that influence farmers' technology adoption was presented. These factors included farmers' socio-psychological, economic and social aspects as well as the farmers' resources and the farm climatic/infra-structural conditions and, finally, the technology attributes that, in many cases, relate to farmers' subjective assessment of these attributes rather than their objective characteristics. An overview of other external factors to the farming systems was also presented since these factors provide the context in which technology adoption decision is made.

As shown throughout this chapter, there is voluminous body of literature involving technology adoption decisions. It comprises a large variety of technologies, countries, several stakeholders, different methodological approaches and diverse research objectives. Given the diversity in terms of contexts for adoption decisions, the literature is not unanimous about the impact of the various identified factors on technology adoption. Neither is the literature unanimous regarding the extent of the impacts. It would appear technology adoption is context sensitive. Variables relevant in a particular location, related to a particular group of people or technology may not be extrapolated to a different context because the adoption behaviour is a result of complex interactions of numerous variables. Nonetheless, some patterns were observed. Divisible technology, for instance, is more easily accepted by farmers. This type of technology enables gradual implementation, allowing farmers to observe, experiment and learn from trialling before full implementation. Also, farmers who are 'easy going', curious by nature, open to others' opinions and have a large social network are more likely early adopters. Likewise, large farms are more likely to adopt innovations than small farms not only because of wealth status but also because they are more likely to benefit from external components of the farming system, such as access to information and markets, extension services, and agricultural credit among other factors.

However, there are some gaps in the adoption literature. Historically, most studies have focused on technology diffusion (adoption at a macro level), with emphasis on the rates and speed of adoption. Despite the importance of such studies for policymakers, they lack an assessment of farmers' perspectives. Increasingly, the farmers' socio-psychological aspects have been incorporated in the body of literature. The methodological approach undertaken in this research is in line with this trend, as it is explained in the next chapter (Chapter 5).

Another gap relates to the scope of studies on technology adoption. While crop technology, and more recently, agroforestry and environmental-related practices, have been considered Gillespie *et al.* (2007) and Ward *et al.* (2008) noted that cattle technologies have been overlooked. Moreover, a considerable volume of research has been devoted to analyse technology adoption in African countries, where the reduction of poverty and hunger has often been a priority underlying decisions. The motivation is considerably different from market-oriented farmers, even in other developing countries like Brazil. Similarly, technology adoption studies in Europe, United States and other developed countries may be of little applicability worldwide, given the high levels of agricultural subsidies and considerable institutional support available to farmers. Very few studies approached the problem of agricultural technology adoption in Brazil, a gap that must be filled.

This research attempts to address these gaps, enlarging the scope of adoption research in three ways: (1) by addressing beef cattle farmers' technology adoption decisions; (2) by considering not only environmental, but also production and managerial technologies; and (3) by providing a better understanding of Brazilian farmers' technology adoption behaviour, particularly among commercial family farms. These farms contribute significantly to Brazil's agricultural production and exports, as described in Chapter 2.

In the next chapter (Chapter 5), the methodological approach is described in detail.

Chapter 5
Research Approach

5.1 Introduction

In the last three chapters, a comprehensive review of the literature pertinent to this study was presented. Brazilian beef production systems were reported and the gaps in need of research were highlighted. Then, the main decision theories and models were discussed and factors determining technology adoption decisions worldwide reviewed. These provided the theoretical background necessary to justify the research approach discussed in this chapter.

First, the philosophical basis of the research is presented, giving support to the theoretical framework and the research methods. These are discussed in detail and are translated into the research strategy (multi-case study), which is explained subsequently. The rationale for the sampling frame is provided along with the procedures for data collection, processing and analysis. Next, some methodological limitations are pinpointed and ethical considerations made. Finally, the chapter is summarised.

5.2 Research Paradigm

A paradigm is a set of beliefs which provide guidance as to how the world is seen and acted upon (Guba, 1990, p. 18). The paradigm, thus, establishes the philosophical basis upon which research is built and interpreted. It is defined on the basis of ontology, epistemology and methodology. Ontology is the *assumed* nature of reality (Davidson & Tolich, 2003; Patton, 2002; Sarantakos, 2005). Ontology considers people's beliefs about reality and what is 'real' for them (e.g., some people believe in God; others do not). Epistemology, in turn, is concerned with how people know what they know and what counts as legitimate knowledge (e.g., the reasons/evidence for the (dis) belief in God). In this sense, epistemology is related to the nature of knowledge (Davidson & Tolich, 2003; Sarantakos, 2005). The ontology and epistemology are philosophical concepts which bring to light the researchers' beliefs and assumptions of reality and their subjective assessment of 'legitimate' knowledge. These assumptions guide the researchers' choice of methodology. The methodology, therefore, translates the ontological and epistemological principles into guidelines that define the way research should be constructed and conducted (Sarantakos, 2005).

Different ways of perceiving the world, i.e., different ontological and epistemological assumptions, gave rise to several research paradigms (Sarantakos, 2005). From an ontological perspective, major paradigms are oriented to ‘reality’ or to ‘constructions of reality’. According to Patton (2002), the positivist and post-positivist paradigms are ‘reality-oriented’, with both assuming that there is a ‘real’ world that can be understood, analysed and measured. In this ‘real’ world, research attempts to find universal laws (or the ‘truth’). These two paradigms distinguish genuine knowledge (i.e., scientific knowledge) and belief (i.e., no empirical verification). The main difference between the positivist and post-positivist paradigms is that, according to Campbell and Russo (1999, as cited in Patton, 2002, pp. 92-93), the latter admits knowledge about the ‘real’ world is limited and relative (rather than absolute). Given this limited understanding of the social world, knowledge is obtained through the falsification of hypotheses rather than the confirmation of facts. Furthermore, post-positivism recognises that judgement is unavoidable in science and all methods are imperfect, so the application of multi-methods over time is required to generate and test theories on how the world operates.

Patton (2002) explains that constructivism is an alternative paradigm that proposes that the human world is different from the natural world, and studies on these should be different too. This is in sharp contrast with what positivists believe. Constructivism assumes that reality is socially constructed based on the way people *“make accounts of the world and gain impressions based on culturally defined and historically situated interpretations and personal experiences”* (Sarantakos, 2005, p. 37). Consequently, there are multiple realities constructed by people; the research role, then, is to describe these realities and understand the implications of the constructions to people’s lives and social interaction. Thus, research becomes context sensitive, with the findings representing another construction to be taken into account in the search for consensus (Patton, 2002; p. 98).

In this study, it is assumed that farmers, as part of a social system, socially construe their world on the basis of their ‘knowledge’, beliefs and experiences. Consequently, different farmers may construe technologies differently, both from their peers and from researchers. Therefore, farmers’ mental constructions of the phenomenon under investigation (i.e., technology adoption) must be accounted for if researchers want to understand the phenomenon more comprehensively. Ontologically, this is in line with constructivism, which is the paradigm under which this research is taken.

The epistemological base of this research is rooted in ‘interpretivism’. Interpretivism assumes that people assign meanings to their activities (subjective meaning) in order to make sense of their world, encompassing natural events, social situations and other people’s and their own behaviours (Blaikie, 1993, p. 36). People’s interpretations of the objective reality support their social system beliefs. Interpretive research, in this context, systematically analyses socially meaningful action in order to understand how people create and maintain their social worlds (Davidson & Tolich, 2003, p. 26).

Critics of the interpretive research include Giddens (1984, as cited in Blaikie, 1993, p. 111), who points out that underlying interpretivism is an assumption that social actors engage in continuous monitoring and are aware of both their intentions and reasons for their actions. Giddens (ibid) argues, however, that most of everyday actions happen without reflective monitoring and that social actors only think about their actions when recalling the past or queried by others.

Despite this criticism, an interpretivist orientation seems to suit the study of technology adoption decisions, since these are unlikely to be routinised by farmers as they probably consider the 'pros' and 'cons' before applying a new technology. Therefore, this research assumes that farmers (decision-makers) make purposeful and *rational* adoption decisions, based on the best of their knowledge, to achieve multiple objectives; also, they are able to communicate these decisions and the reasons based upon which they reach an outcome (e.g., adoption of a technology).

The ontology and epistemology underpinning this study have been constructed on the basis of the researcher's subjective assessment of farmers' nature, very much influenced by her professional experience as a participant observer of the Brazilian beef industry (social system) over five years prior to undertaking this research. Despite this relationship with the beef industry, the researcher was unknown to all participants and all the views reproduced in this study were as faithful as possible to the farmers' worldviews, without judgement. However, the role of the researcher as an active element of the research, co-constructing the findings, is acknowledged, as farmers' worldviews are brought to light through the researcher's lens of inquiry and interpretations. Triangulation of methods and data are used to support the researcher's findings and ensure internal validity.

A qualitative methodology naturally follows from the constructivist-interpretivist paradigm, which is used to explore in depth farmers' worldviews and the complexities involved in farming decisions in particular. The qualitative approach in this study is oriented to the exploration and discovery of the phenomena under investigation (i.e., decision-making and technology adoption). Hence, inductive logic is predominant, aiming at theory generation rather than theory testing. The inductive approach is not guided by theoretically derived hypotheses, but by questions in the search for patterns within the subjects (Patton, 2002, p.

56). Deductive logic may also be applied for specific situations. The combination of inductive and deductive logic is consistent with Davidson and Tolich's (2003) claim that there is no such research that is purely inductive or deductive.

Besides the inductive logic, other principles of inquiry also underlie the qualitative philosophy. A summary of the main principles was presented by Patton (2002, pp. 40-41) and is reported below.

- Naturalistic inquiry: the focus of the inquiry is to explore naturally occurring events and whatever emerges from them (as opposed to controlled experimentation, for instance). It is particularly useful when the researcher wants to capture relevant individual differences between various participants' experiences and outcomes.

- Design flexibility: the research design is flexible and change as new insights and knowledge emerge (as opposed to rigid designs). Qualitative inquiries usually count on general guidelines, which may be enriched during the data collection process, to allow for exploration of emergent, often unexpected, themes.

- Purposeful sampling: cases are purposefully selected because they are 'information rich'. Sampling is aimed at insight about the phenomenon rather than empirical generalisation from a sample to a population.

- Qualitative data: observations that provide thick descriptions, usually including direct quotations of people's viewpoints.

- Personal experience and engagement: the researcher's personal experiences and insights are relevant for the inquiry and often fundamental to the understanding of the phenomenon. This is in stark contrast with quantitative inquiries, which emphasise detachment and distance.

- Empathic neutrality: during the interview, the role of the researcher is to be fully present (mindfulness) with the interviewee, being respectful, sensitive, responsive but not judgemental.

- Unique case orientation: each case is unique and contributes to the overall understanding of the phenomenon. Therefore, the inquiry is aimed at insights about individual cases, at first stance, which are then used in cross-case analysis to 'capture' the phenomenon as a whole.

- Holistic perspective: the holistic approach assumes that the whole phenomenon is greater than the sum of its parts. In studies of complex social systems, a reductionist approach seems to have limited power to address the complexities and interconnectedness of such systems, in which case a holistic approach is more suitable.

- Context sensitivity: findings are sensitive to social, historical and temporal context. Thus, any generalisation across different contexts must be undertaken very carefully. Instead, the emphasis is on comparative case analysis with exploration of possible transferability and adaptability of patterns in new settings.

- Voice, perspective and reflexivity: given pure objectivity is impossible and pure subjectivity is not recommended, the researcher must balance objectivity and subjectivity, being reflective about his/her own voice in the findings.

5.2.1 Other theoretical orientations

The constructivist-interpretivist paradigm is overarching for this qualitative study of technology adoption decisions of innovative beef farmers. Under this paradigm, various theoretical orientations were given consideration to address the research questions. These theoretical orientations include the theory of real life choice (TRLC), the personal constructs theory (PCT), soft systems thinking (SST) and Grounded Theory (GT). The first two (TRLC and PCT), discussed in detail in Chapter 3, provided the framework for the study of farmers' decision making whereas the latter two (SST and GT) provided some overall guidelines of inquiry. SST and GT are discussed next.

5.2.1.1 Soft Systems Thinking (SST)

In a comprehensive review of Systems Thinking, Checkland (1999) argues that the work by Checkland (1981) established the grounds of this approach by applying engineering concepts to try to understand complex problem situations in need of improvement. The main assumption of systems thinking is that the behaviour of the parts of a complex system is different when isolated from its environment or other parts of this system. This is in sharp contrast with the traditional reductionism of natural sciences. The reductionist approach promotes the reduction of a complex system to its fundamental parts in order to make sense of the problem situation.

System thinking, therefore, undertakes a holistic approach to gain insights into the whole system by understanding the linkages and relationships among its components. It acknowledges that events are spatially and temporally separated and a small change in one component may largely affect the whole system. It proposes a different way of thinking about the world and its complexity (Checkland, 1999).

The dictionary defines system as *"a regularly interacting or interdependent group of items forming a unified whole" (Merriam-Webster, 2011)*. Checkland (1999, p. 3) further developed this definition and applied it to his field of knowledge, advocating that a system is *"a set of elements connected together which form a whole, this showing properties which are properties of the whole, rather than properties of its components parts"*. Examples include natural, human, social and political systems; all of which can be studied using systems thinking. System thinking recognises that all human activities are open systems and, as such, they are affected by the environment in which they exist (Checkland, 1999; Checkland & Poulter, 2006).

System thinking includes 'hard' and 'soft' methodologies (Checkland, 1999). In hard systems thinking (HST), the world is seen as several interacting systems, some of which are in need of intervention to work better (Checkland, 1999, p. A-10). According to Daellenbach (2001), HST has been successfully applied to technically complex problem situations but with low human complexity or low divergent views on the subject matter. Its focus is on problem-solving, commonly using simulation, statistics and mathematical models to tackle typically quantifiable problems.

In soft systems thinking (SST), the process of inquiry is *systemic* but not the world itself, as in HST (Checkland, 1999, p. A-10). SST sees a world that is complex and chaotic and, in order to make sense of it, proposes a systemic approach to problematic situations (Checkland & Poulter, 2006). Soft systems thinking is particularly useful when the problem situation is not easily quantifiable, is ill-defined or ill-structured or when there exist complex human affairs (Checkland, 1999; Checkland & Poulter, 2006). Motivations, viewpoints and decision making are some examples of suitable subjects to be addressed by a SST methodology.

The major focus of SST is on structuring and improving the problem situation rather than problem-solving. Consequently, modelling in SST assumes a different dimension compared to the typical optimisation of HST, as illustrated by Checkland (1999; p. 191):

> *"human activity can never be described (or 'modelled') in a single account which will be either generally acceptable or sufficient. (...) the characteristic of the real world forces the methodology to become a means of organising discussion, debate, and argument, rather than a means of engineering efficient 'solutions'".*

The above extract suggests what Checkland and Poulter (2006) later made clear: that one of the assumptions underpinning SST is the existence of multiple and conflicting worldviews in human affairs. This assembles an interpretive orientation, as highlighted by Daellenbach (2001). Daellenbach (ibid) points out that in SST the accounts of a given problem situation reflect the observer's worldview and, thus, are not assumed as the objective reality. These accounts are seen as the observer's personal conceptualisation of useful and convenient aspects of the phenomenon and their interconnectedness, which enables a better understanding of this phenomenon and an improvement on the problem situation.

A soft systems thinking was applied in this study that deals with complex human affairs (i.e., technological decision making) under a constructive-interpretive framework. Here, technological decision making was seen not as one isolated activity whose understanding depended solely upon the discovery and description of its components; nor was it seen as a linear sequence of steps (described in Chapter 3) intended to optimise farmers' processes of decision making. Rather, decisions were analysed systemically, in their natural context, considering their various variables and their multifaceted interactions. In acknowledgement that different innovative farmers have diverse accounts of technology adoption, with direct effect on their decision making processes, decisions were modelled in order to make sense of this diversity and to provide useful insights into these farmers' rationale. Using Grounded Theory, discussed next, and other methods, these accounts were mapped and analysed, originating theories on innovative beef farmers' technology adoption behaviour.

5.2.1.2 Grounded Theory

Grounded Theory (GT) was developed by Glaser and Strauss (1967) and is directed to the process of theory building rather than theory testing (Patton, 2002; Sarantakos, 2005). As a methodology for building theory, it is mainly inductive and relies on systematic procedures to generate theories grounded in data (Charmaz, 2006). It contrasts with theory generated by deductive logic, which is established based on *a priori* assumptions (Glaser & Strauss, 1967; Patton, 2002). Strong emphasis is placed on the researcher as an element of the research process in GT. This means that both the object of analysis and the interpreter (i.e., the researcher) are important for the understanding of the phenomenon under study (Sarantakos, 2005).

Through the analysis of Charmaz's (2006, pp. 4-9) review of literature, it is possible to identify three main approaches to Grounded Theory: (1) the use of GT as a method of discovery, as originally proposed by Glaser and Strauss (1967); (2) a systematic approach to GT suggested by Strauss and Corbin (1998) to ensure rigor in theory generation; and (3) a constructivist approach. The original Grounded Theory, from Glaser and Strauss (ibid) heavily relied on empiricism. Through intense comparative analysis among cases, patterns arise, making the grounds for theorisation (Babbie, 2004, p. 374). According to Charmaz (2006), the systematic approach from Strauss and Corbin (ibid) represented a departure from the strong empiricism posed by Glaser's approach, strongly emphasising systematic procedures and moving the method toward verification. In common, both approaches to GT were taken under a positivist paradigm. In contrast, Charmaz (2006) proposed the use of principles and practices of GT under a constructivist-interpretive paradigm. In her view, data and theories are not discovered in GT. She argues that *"we construct our grounded theories through our past and present involvements and interactions with people, perspectives and research practices"* (Charmaz, 2006, p. 10).

Engaging in research involving GT requires the consideration of some common themes, irrespective of the approach undertaken. These themes have been described by various researchers (Charmaz, 2006; Dick, 2005; Mills, Bonne, & Francis, 2006), as follows.

- Theoretical sensitivity: refers to the researcher's sensitivity and openness to various theoretical possibilities, avoiding attachment to a particular direction that is taken for granted (i.e., involves constant attempts to disprove it).

- Theoretical sampling: means to sample with the aim of developing the categories (or theories) of interest. In this case, sampling focuses on people and events that elucidate the phenomenon.

- Constant comparative method: this is the core of theory development, with the generation of abstract concepts through successively comparing data, categories and, finally, these with theories.

- Coding: is a thorough process of analysis of qualitative data (e.g., farmers quotes) to identify emerging themes, defined by what the researcher sees in the data and, to which, qualitative labels (codes) are applied.

- Core category and saturation: usually, several themes (or categories) emerge from data. However, it is recommended that categories are analysed one at a time, with the core one launching the process. When the research reaches a point of diminishing returns, i.e., interviews add no new information about that category, saturation is achieved;

▪ Memoing: is the process of taking notes of insights (or hypotheses) the researcher has during the data collection, coding and analysis about a category or about the relationships between categories. It captures diverse perspectives of the theory emerging from the data.

▪ Treatment of the literature: background reading (initial literature review) prior to data collection is not privileged in GT studies because there are concerns that preconceived ideas may constrain the coding and memoing processes. Rather, literature is treated as data and is assessed as it becomes relevant to the emerging theories.

Following Charmaz’s (2006, p. 11) constructivist propositions, the basic steps of Grounded Theory include: the preliminary exploration of a research problem and open research questions; initial data collection and coding; initial memos attempting to raise codes to tentative categories; further data collection; advanced memos refining categories; theoretical sampling seeking for specific data; theoretical memo-writing and further refinement of concepts; sorting memos; integration of memos and diagrams of concepts; and writing the draft. Although these steps are presented linearly, in practice they are fuzzy, with the researcher taking loops constantly, re-examining earlier data, assessing early memos and moving from data collection to data analysis and back to further data collection as many times as necessary to ensure sound theory generation. As Charmaz (2006, p. 188) draws attention for, in Grounded Theory the distinction between data collection and analysis is intentionally blurred, which is in sharp contrast with traditional research.

Despite the widespread use of Grounded Theory in social sciences (Patton, 2002), it was not without criticisms. Lamnek (1988, cited in Sarantakos, 2005) pinpoints some of the most recurrent critiques of GT:

▪ the notion of no preconceptions when starting the research is questionable;

▪ the researcher personal involvement in the research raises the point of subjectivity and validity of the findings;

▪ the data collection process is not very clear as there is no information about what is useful, suitable and theoretically relevant to be included in the study;

▪ the method of theory building is not precise; and

▪ the notion of theory being ‘grounded in data’ betrays objectivism.

In this study of innovative beef farmers, Grounded Theory was taken under the constructivist approach advocated by Charmaz (2006) and Mills (2006). This is in acknowledgement that the findings of this study are another construction (the researcher's) of these farmers' social reality and are not intended to represent a universal truth. Findings aim at throwing light on the phenomenon under investigation (technology adoption), enhancing the overall understanding of it. With this purpose, some elements of Grounded Theory were used in combination to other theoretical and methodological guidelines, as per triangulation of methods (and data). These elements are theoretical sensitivity and sampling, comparative methods (also recommended in Ethnographic Decision Tree Modelling, discussed later), coding, memoing and data saturation. However, the coding did not follow strict procedures recommended by GT because the interviews were not fully transcribed, but only some of its parts. The coding and the subsequent memoing often occurred during the listening, and translation, of the interviews. Other details on the specific procedures of data collection and analysis are provided in Sections 5.3.3 and 5.3.4.

The distinctive treatment to the literature suggested by GT was also not followed closely. The literature review in GT is usually delayed either because with emerging fields of knowledge the literature is limited or to avoid having preconceived ideas guiding the coding and memoing processes. However, neither was the subject matter (technology adoption) new in the literature nor was this literature unknown by the researcher. Therefore, it is acknowledged some preconceived ideas at the start of the research process were inevitable. Being theoretically sensitive was a way of mitigating this issue, though. Additionally, overlooking what had been done in the field of technology adoption, whose body of knowledge is already significant, would be risky as the researcher would not be sensitised for relevant issues related to this topic. For these reasons, some literature was reviewed during the project stage, some during the preliminary data analysis and large revisions were left to the writing up stage.

5.3 Research Methods

The choice of particular methods to address the research questions (Chapter 1) must be consistent to the research paradigm and the theoretical framework proposed in a study (Davidson & Tolich, 2003; Sarantakos, 2005). Although it is acknowledged that there are several methods suitable to this investigation, some were more appealing than others, being in alignment with the interpretivist-constructivist paradigm and the qualitative nature of this research. This was the case of ethnographic decision tree modelling (EDTM) for the study of farmers' decision making and the Q-methodology for gaining insights into farmers' major values and goals. The background technique of these methods is described next; the specific steps for data collection, processing and analysis undertaken within each of these methods are presented in subsequent Sections (5.4.3 and 5.4.4).

5.3.1 Ethnographic Decision Tree Modelling (EDTM) – technique background

Ethnographic Decision Tree Modelling (EDTM) is used to gain understandings about how individuals make real world decisions. The method allows for the decision makers to elicit themselves the decision criteria, which are organised in a decision tree frame, based on 'if-then rules' (Gladwin, 1989). Models are developed based on individuals' own terms and criteria that they actually use to make decisions.

There are common principles underlying decisions and, therefore, the construction of the ethnographic decision tree models. Firstly, Gladwin's (1989) model assumes that people (e.g., farmers) compare alternatives when making decisions. An alternative (e.g., artificial insemination) has a set of aspects or characteristics and each aspect is one dimension of an alternative (e.g., ease of use). All aspects are discrete and assume probabilities of one or zero (i.e., true or false). When the aspect is a continuous variable, such as cost, it is treated as a constraint by the decision maker (e.g., is the cost < 'X'?). Secondly, aspects are ordered in such a way that alternatives of choice are set at the top of the tree, the decision criteria at the nodes and the outcomes at the ends of the tree, providing several decision paths (i.e., different combinations of criteria). This ordering of aspects gives the model a hierarchical frame.

Within this hierarchical frame, the decision making process occurs in two stages. In the first stage, known as 'elimination-by-aspects' (Tversky, 1972, as cited in Gladwin, 1989), alternatives with unwanted aspects are eliminated without further thought, often subconsciously (e.g., elimination of artificial insemination – AI – if the farm has no breeding herd). The second stage is the *"hard core"* part of decision making, that is, the conscious and thoughtful stage of the decision process (Gladwin, 1989, p. 20). During this stage, individuals rank relevant ('emic') aspects and compare alternatives based on these aspects (e.g., availability of qualified staff to carry AI, cost of equipment and semen, difficulties found etc). Among all alternatives entering the second stage of decision making, the one that passed through all aspects and ranked highest in a major aspect is the chosen alternative. Gladwin (1989, p. 20) argues that this ordering of aspects assembles the economists' *"maximisation subject to constraints"*.

To elicit these aspects, or decision criteria, Gladwin (1989) suggests the ethnographic interview and participant observation (i.e., triangulation of data to ensure internal validity of the model). Decision criteria are elicited by contrasting decision behaviour over time, space, and decision makers. After elicitation, decision criteria are then organised in a decision tree frame, based on ‘if-then rules’. Gladwin (ibid) explains that a decision tree can be constructed for individual farmers and then combined into a composite model (direct method). Alternatively, it can also be built indirectly through continuous review and improvement of the model, as new informants are interviewed (indirect model). A detailed explanation on how to build the composite model is found in Gladwin (1989, pp. 39-45).

When used under a quantitative approach, EDTM has been tested against empirical data, predicting between 80 and 95% of decisions (Gladwin, 1989; Jangu, 1993). However, in qualitative studies like this, testing the model is not a concern. The model aims at organising empirical data in such a way that patterns become evident, improving the understanding of the phenomenon under investigation (as opposed to testing hypotheses). Thus, no model was tested, but was considered useful when it enabled a better understanding of decision making processes of the innovative beef farmers investigated here.

5.3.2 The Q Methodology – technique background

According to Addams (2000) and McKeown and Thomas (1988), the philosophical, technical and statistical foundations of Q methodology were established by William Stephenson (1935), who applied it in behavioural research. Further developments are attributable to Brown (1980), who applied the method in political sciences studies. Q-methodology proposes a method for statistically dealing with human subjectivity (McKeown & Thomas, 1988, p. 12). In this respect, it differs from purely qualitative or purely quantitative methods, as Addams (2000, p. 14) highlights: *“Q methodology combines the openness of qualitative methods with the statistical rigour of quantitative research analysis”*.

The method acknowledges there are diverse worldviews and offers a way of identifying these worldviews, also called ‘discourses’, and systematically examining the meanings behind the words. As Addams (2000, p. 17) points out, Q methodology allows people to ‘speak for themselves’ by incorporating subjectivity into the analysis. Subjectivity here means the communication of one’s point of view (i.e., innovative farmers). Therefore, in Q methodology, subjectivity is always anchored in one’s personal frame of reference (self-reference). The basic assumption of subjectivity being self-referent however does not preclude rigorous analysis. The premises of Q methodology, thus, make this method of great value for this study of farmers’ values and goals.

Q methodology had its origins in the factor analysis technique, commonly used in quantitative studies. According to Fairweather (1990), the method is based on correlating subjects according to the similarities of their worldviews. It consists of modelling people's viewpoints by means of a Q-sort, that is, a rank-ordering of purposively selected statements (or other stimuli) pertaining to the domain of the issue at hand (McKeown & Thomas, 1988). The rank-ordered array of statements defines the Q-sort for a subject, which reveals what is relevant for him/her, based on his/her frame of reference (Fairweather, 1990, p. 3). Q-sorts from all respondents are then correlated and factor analysed in order to yield groups of people who have ordered the statements similarly (i.e., have similar discourses). In this process, statements have little importance by themselves; more important is the relationship among statements, which is revealed by the way they are sorted by all respondents (Addams, 2000; Brown, 1980; McKeown & Thomas, 1988). The resulting factors represent viewpoints, with each statement being 'scored' for each factor. Thus, each factor has a particular array of statements (factor array), whose ranks in the arrays determine which statements are statistically different from any pair of factors. Respondents' association with each viewpoint (i.e., factor) is indicated by the magnitude of his/her loading on that factor (McKeown & Thomas, 1988). Interpretation of factors and their array of statements occur by consistently producing explanations for the factor arrays.

Fairweather (1990, pp. 3-4) highlights that while in Q methodology persons are correlated and factored, in a typical factor analysis, namely the R-method, the correlation and factorisation occurs amongst traits. This means that the unit of measurement of the factor analysis varies between Q and R. In R, *N* traits represent different variables (e.g., age, education, and farm area), each carrying its own properties, which, once correlated and factored, give rise to clusters of traits (or factors). In contrast, Q methodology correlates subjects with one another to produce factors that link them together, based on the similar scores of their Q-sorts. Therefore, in spite of using traits (and their various units of measurement), a common unit of measurement is used in Q factor analysis, namely, 'self-significance'. As McKeown and Thomas (1988, p. 48) explained, the only measuring unit in Q is the psychological significance of each statement for each individual. This significance is established on the basis of the relative position of statements in the Q-sort (Addams, 2000). Given the self-significance of measuring units, validity occurs internally rather than externally, since there is no external criterion for a person's own point of view (Brown, 1980, pp. 174-5). Despite this conceptual difference, the specific procedures of factor analysis in both Q and R are statistically similar (McKeown & Thomas, 1988, p. 49).

The interpretation of the results requires the use of known facts about each factor for developing a plausible explanation. The process proceeds continuously until the best explanation is developed. Socio-economic data can be also analysed to aid the factor interpretation and highlight any relationship of particular data with particular factors (Addams, 2000). Finally, labels are typically established for each factor with the intention of pinpointing its salient characteristics which summarises the viewpoints this factor represents (Schlinger, 1969, as cited in Addams, 2000, p. 33).

Q methodology has been applied in several studies focusing on different themes, industries and stakeholders, and increasingly in rural research, as pointed out by Previte, Pini and Haslam-McKenzie (2007) who carried out a comprehensive literature review on this theme. In common the studies shared the endeavour to capture people's values, goals, beliefs, preferences and attitudes. For example, Q methodology was used to identify management styles (including sets of goals) among farmers in New Zealand (Fairweather & Keating, 1994). The sorting of 45 statements under three themes (business, lifestyle and family) by 50 subjects resulted in the identification of three management styles: the dedicated producer, the flexible strategist and the environmentalist. Brodt *et al.* (2006) also used Q method to gain insights on management styles, with the purpose, though, of advancing biologically based farming practices among almond and wine grape producers in California. In this study of Brazilian innovative beef farmers, Q-methodology is used to identify and group their major values and goals which may, or may not, impact on their adoption behaviour.

5.3.2.1 Purposive sampling of statements (Q-sample) and subjects (Q-set)

The population of statements can be sourced from the literature, experts' opinions, people affected by or affecting the phenomenon and also from the researcher's own experience. The selection of statements from this population usually yields a range of 30 to 50 sentences in an attempt to ensure diversity (Addams, 2000). Representativeness of views is ensured by stratifying statements based on relevant aspects (i.e., dimensions) associated with the phenomenon under investigation. This representativeness is established on the basis of the diversity of views entailed within statements rather than the proportion of the views among the population. Once statements are selected, they are written in colloquial language to avoid noise in the communication with the subjects (Fairweather, 1990).

Alike the sampling of statements, breadth and diversity are more important than proportionality in the selection of subjects, namely Q-set (Brown, 1980, p. 260). Fairweather (1990, p. 5) explains that, when establishing the Q-set, there is no concern about the frequency of the ideal types (hypothetical persons represented by the factors) in the population and, therefore, there is no need for random sampling. Rather, the premise is to have enough subjects (at least four) to establish a factor (Brown, 1980). Given the selection of subjects endeavours to reach diversity of viewpoints, it typically requires from 20 to 50 subjects.

In this research, Q methodology was applied to identify the major goals and values of Brazilian innovative beef farmers and determine whether there was diversity among them. Following a similar procedure undertaken by Fairweather and Keating (1990), an initial list of 133 statements was drawn from the literature (Cezar, 1999; Costa, 1998; Fairweather & Keating, 1990; Gasson, 1973; Ohlmer *et al.*, 1998; Wallace & Moss, 2002) and was complemented by some of the researcher's personal contributions. These statements comprised three themes (business, family and lifestyle) and 18 dimensions: risk control, core business, development, independence, financial security, ease care, marketing, debt, succession, intergenerational relationships, goals for children, role men/women, status, lifestyle, aesthetic/conservation, country life, challenge and later life. After three revisions, the final list contained 49 statements, being 61, 31 and 8 percent of business, lifestyle and family statements, respectively (Appendix A). These statements were tested in a pilot test with one innovative farmer (as described in Section 5.4.3) and were further refined, being written in a colloquial language and printed in cards (usually 500 mm x 400 mm).

The definition of the Q sets (subjects) is presented later in this chapter (Section 5.4.2.2.) because other theoretical guidelines were also given consideration.

5.4 Research Strategy

The strategy used in this research was the case study approach. In this section, this strategy is discussed and the particular cases of interest appointed. Explanations on the sampling frame, the data collection procedure and data processing and analysis are also provided. The philosophical framework supporting the choice of a case study strategy was discussed in the previous sections.

5.4.1 Case study

The use of case studies is one of several strategies in social investigations. Although there is no clear-cut typology to define research strategies, Yin (2009, pp. 8-10) suggests that the choice of a research strategy depends on the type of research questions, the extent of control the researcher has over the behavioural event and the type of event (historical versus contemporary). In the study of contemporary behavioural events that require no control over these events, Yin proposes that case studies and surveys are the most appropriate research approaches: in the study of frequencies or incidence, survey is recommended as it allows for ‘what’, ‘how many’ and ‘how much’ types of research questions to be addressed; in studies involving ‘how’ and ‘why’ questions, case studies are more suitable as they allow for deep exploration of the phenomenon. Although experimentation also focuses on ‘how’ and ‘why’ types of questions, it requires control over the behavioural event. In this study of innovative beef farmers, the research questions are mainly of ‘how’ and ‘why’ types (Chapter 1) and there is no need for controlling these farmers’ adoption behaviour as the aim is to understand this phenomenon in its natural settings. This justifies the choice of a case study as this research strategy.

Case study as a research strategy has been largely adopted in qualitative studies. This method enables the understanding of the real-life events in a holistic and meaningful way (Yin, 2009, p. 4). A case study is an in-depth investigation strategy that can involve a unit as small as an individual or as large as an entire community (Sommer & Sommer, 1986). It can also involve a single case or multi-cases. Often, the study of cases has an exploratory character, although Yin (2009) claims that it can also be used in descriptive and explanatory inquiries.

The case study strategy provides the opportunity to apply a multi-method approach to a unique event (Yin, 2009, pp. 62-63). Cezar (1999) corroborates, pointing out that case studies are useful to complement and enhance quantitative studies, providing detailed information of relevant cases. In the particular case of beef production systems, Nocetti (1971) argues that case studies are especially useful because they:

- provide information about production levels within different ecological conditions;
- allow for the gathering of rich information in a short time frame;
- account for scale of beef production; and
- give insights into the herd dynamic and its relationship with the whole system.

There are also some criticisms of case studies. According to Yin (2009) and Sarantakos (2005), case studies have been criticised for lacking in scientific rigour as there is not a systematic procedure to be followed (i.e., as in other research strategies). Sarantakos (2005) explains that the findings entail personal impressions, and possibly biases, affecting the study objectivity, validity and reliability. This argument assembles the positivist thinking, which defends that the researcher should remain separate from the researched. Under the constructivist-interpretivist approach undertaken in this thesis, however, the researcher as an active part of the research process is acknowledged and subjectivity accepted, as discussed in previous sections. Issues of validity and reliability were addressed by means of data and methods triangulation so that equivocal evidence was avoided and claims were supported by multiple data sources.

Another common criticism is the lack of a basis provided by case studies for scientific generalisation (Yin, 2009, p. 15). The commonly reduced number of cases investigated and the context-sensitivity of the findings are the reasons for questionable generalisation from case studies. The counterargument is that the findings provided are generalisable to theories and not to populations, as the objective of such a research strategy is to expand the theoretical basis rather than establish frequencies. Other scholars argue that qualitative findings can be moderately generalised to populations as well (Williams, 2000, as cited in Payne & Williams, 2005). 'Moderatum generalisations' are moderate claims about the social world that do not 'hold true' over the long run or across cultures, but go reasonably beyond the individual cases (Payne & Williams, 2005). Underlying these moderate claims is the assumption that where certain qualities (and their structural characteristics) of the phenomenon exists elsewhere, then the same or similar characteristics apply.

In this research, a multi-case study was conducted with 26 innovative beef farmers (units of analysis) in *Mato Grosso do Sul* State, Brazil. The case study strategy was designed to explore the phenomenon of decision making and technology adoption in a holistic way, combining qualitative and quantitative methods under a qualitative framework. Despite the prevailing exploratory character of this research, it also incorporated descriptive and explanatory elements. Findings were mainly generalised to theory, although some emerging cross-case patterns are arguably found within the population as a whole, justifying the use of the 'moderatum generalisation' in this particular circumstance. For instance, the farmer types defined in Chapter 6 may also be found in the wider population of beef farmers in *Mato Grosso do Sul* State, although the frequency of each type is unknown and other farmer types may exist.

The source of innovative beef farmers (cases) for this study and the sampling frame are discussed in the following section.

5.4.2 Sampling frame

There are two categories of sampling: probability-based and non-probability based sampling. Typically, quantitative studies use probability-based sampling techniques to ensure randomness and representativeness so that the results can be generalised to a population (Patton, 2002). The logic behind qualitative studies, though, is to sample relevant cases so that the phenomenon of interest can be investigated in depth. Hence, non-probability sampling is usually employed in order to ensure that the selected cases are information-rich and can enhance researchers' understandings of the issue being studied (Sarantakos, 2005).

There are several probability and non-probability based sampling techniques (for a summary, see Patton, 2002, pp. 243-244). Among probability-based sampling the most common techniques are simple or stratified random sampling. In simple random sampling, every element of the population has equal chance of being selected, allowing for generalisations from the sample to the population. A more advanced technique is the stratified random sampling which enables generalisations to be extended to particular subgroups within the population, but more importantly, ensures each sector is represented in the total sample. Among the non-probability based (or purposeful) sampling techniques, those with possible application in this study are: maximum variation sampling, snowball sampling, critical sampling, criterion sampling, theoretical sampling, and mixed purposeful sampling.

In this study, a mixed purposeful sampling was adopted combining non-probability and probability based techniques, according to specific circumstances. These circumstances and the associated sampling techniques adopted are discussed next.

5.4.2.1 The research site

The main sampling technique employed for site selection was criterion sampling. This sampling establishes the relevant elements upon which information-rich cases are selected (Patton, 2002, p. 238); in this study, the elements were the relevance of beef production to the regional and national economies (selection criteria). An additional criterion used was farms should be in the *Cerrado* ecosystem, given its importance to the Brazilian agricultural sector (this importance was discussed in Chapter 2). Areas under the *Pantanal* ecosystem were excluded as beef production (and decision making) is severely impacted by environmental aspects (e.g., periodic flooding) (Michels *et al.*, 2001). Another criterion was the potential for innovation and evident expression of innovativeness among farmers. This criterion is relevant as the unit of analysis is *innovative* beef farmers. To a lesser extent, convenience was also considered given the limitation of resources, time and access to farms in some regions. This is in accordance with Patton's (2002) claim that convenience sampling should be the last factor to be taken into account as it usually yields poor results (i.e., when sampling is mainly determined using this technique).

This sampling frame resulted in the selection of the Brazilian State of *Mato Grosso do Sul* (MS) as the research site[9]. This State was purposively selected partially because of the size and importance of cattle to this State. In 2009, *Mato Grosso do Sul* had the third largest cattle herd of the country, with 22.3 million head, behind the States of *Mato Grosso* and *Minas Gerais* (IBGE, 2009). The latter is one of the main Brazilian milk producers, with dairy making up a large part of its herd, with approximately 5.3 million head (IBGE, 2009). Despite the largest cattle herd of *Mato Grosso* State, the State of *Mato Grosso do Sul* has historically ranked first in number of slaughtered animals, resulting in a higher contribution of the beef sector to the regional economy (Meister & Moura, 2007).

Furthermore, the presence of two federal and one state university, numerous private faculties (in agriculture-related degrees), research institutes and three research units of EMBRAPA (EMBRAPA Beef Cattle, Western Agriculture and *Pantanal*) in *Mato Grosso do Sul* State show a favourable environment for innovation to take place. This institutional environment has supported the development and the transfer of agricultural technologies while also providing the market with qualified professionals and consultants. What is more, *Mato Grosso do Sul* was a pioneer in programmes to encourage farmers to invest in technologies and reduce the age at slaughter. In 1992, the State Secretary of Agriculture, Livestock and Development established a programme that reduced taxes on the slaughter of young cattle which complied with the programme regulations (ASPNP, n.d.). This pioneer programme made the grounds for the establishment of the Association of Producers of Young Steers of *Mato Grosso do Sul* State – APYS in 1998. Members of APYS benefit from market alliances established between this association and several partners, including slaughterhouses and retailers. Other innovative programmes include the Brazilian Association of Organic Beef - ABPO, established in 2001 in *Mato Grosso do Sul* (ABPO, 2007) and the Good Agricultural Practices Programme (BrazilianGAP) launched in 2005 by EMBRAPA (EMBRAPA, n.d.).

5.4.2.2 Sampling innovative beef farmers in Mato Grosso do Sul State

A mixed sampling procedure was also undertaken. Initially, theoretical sampling was used to determine the sources of innovative beef farmers. This sampling technique was used because innovativeness and its variants are constructs which do not have a clear frame of reference (as opposed to farm size, for instance). In this case, Patton (2002, p. 238) and Strauss and Corbin (1998, p. 73) recommend that the selection of relevant cases should follow conceptually oriented principles so that the sample becomes representative of the theoretical construct.

[9] The criterion 'Cerrado' limited the research site to the areas under this ecosystem, excluding therefore the 'Pantanal', whose area represents around 25% of *Mato Grosso do Sul* territory (Michels *et al.*, 2001, p. 117).

Innovative beef farmers were identified and purposively selected based on their self-enrolment in innovative initiatives that promote 'good' farming practices. Given the lack of objective parameters to define 'innovative', farmers' participation in innovative initiatives was taken as a proxy for farmers' innovativeness characteristics, with the level of technology adoption being used to determine whether this strategy was effective. The underlying assumption is, therefore, that to engage in innovative initiatives farmers must be willing to innovate and comply with good farming practices required by these programmes. While this pragmatic approach results in the selection of one group of innovative farmers (i.e. enrolled in innovative initiatives), it is acknowledged that there are other innovative beef farmers that were not identified using this criterion and who may or may not have the same reasoning for adopting or not technologies.

Following these premises, two sources of innovative beef farmers were selected: the Good Agricultural Practices Programme (BrazilianGAP) and the Association of Producers of Young Steers of *Mato Grosso do Sul* State (APYS) (refer to Appendix B for details on these). In 2008, there were 16 farmers enrolled in the BrazilianGAP and 120 active members of APYS. From this total, only family farms were eligible for the study (criterion sampling), given the rationale for decision making in corporate farms may vary significantly and the objective of this study was not to compare decision making in these types of farms.

The final sample size was not determined *a priori*, but defined throughout the data collection process as recommended by Grounded Theory (Glaser & Strauss, 1967). Consequently, the inquiry stopped when data saturation was reached and the relevant topics were covered. Indications of data saturation were the repetition of decision criteria and the absence of new criteria for additional interviewees.

Despite the fact the sample size was not pre-defined, as a 'rule of thumb' 45 beef farmers were invited to participate in this study. Although it was anticipated that data saturation would be achieved with less than 45 cases, there was a margin to allow for flexibility if, for any reason, farmers declined participating in the research. From the 16 farmers enrolled in the BrazilianGAP, 15 were invited as one farm was not in *Mato Grosso do Sul* State (i.e., did not match the selection criterion) and was therefore excluded. A stratified random sampling was used to select 30 beef farmers from APYS's 120 active members. Based on herd size, farms were randomly selected so that the sample had ten farms within each herd category: small (less than 1,000 head), medium (between 1,000 head and 3,000 head) and large (more than 3,000 head). This approach was taken to ensure diversity in farm structure and resources.

From the 45 contacted farmers, 27 were interviewed, being 6 from BrazilianGAP and 21 from APYS. The main reasons for non-participating farmers were incompatible dates for the interview and the presence of a mismatching criterion (e.g., corporate farm). One farmer was excluded from the final sample, resulting in 26 valid cases. This excluded farmer completed part of the interview, but was unable to attend to a second meeting because of a serious health problem. From 26 participant farmers, ten had small herds (less than 1,000 head), 11 had medium herds (between 1,000 and 3,000 hd) and five had large herds (more than 3,000 hd).

Besides the 26 farmers upon which the core of this study was developed, eight additional innovative beef farmers were randomly selected from APYS database to enhance the case study on two technologies and further develop the decision tree models. These farmers were interviewed at a later stage using a reduced form of the interview guide (details in Chapter 8).

5.4.2.3 The choice of innovations

There are numerous technologies available to beef farmers. In order to gain holistic insights into the adoption behaviour of innovative beef farmers, a comprehensive set of technologies was selected: it spanned production, environmental and managerial technologies (see Chapter 1 for a discussion on these types) both basic and advanced, ranging from 'soft' to 'hard' nature. Also, selected technologies were likely to be known by most farmers.

Initially, the researcher, using a brainstorm technique, listed 23 assorted technologies. Some environmental technologies were drawn upon the literature. This list was sent by email to several beef specialists (diverse areas of knowledge) from the EMBRAPA Beef Cattle, who suggested another 19 technologies. Later, a focus group was organised with one specialist of each area to discuss the preliminary list of technologies. This discussion led to a final list of 45 technologies, including 25 production, 9 environmental and 11 managerial technologies. The description of each technology is presented in the Appendix C.

A case study was also undertaken with two contrasting technologies with the objective of deepening the understanding of adoption decisions. The selection of these technologies followed the principles of theoretical sampling: they should not only be relevant to beef farming but also provide the accounts of adopters and non-adopters. After a thorough analysis of the 45 technologies, dry season cattle supplementation (i.e., 'hard' production technology) and the cost of beef production (i.e., 'soft' managerial technology) were chosen as cases for further investigation.

According to Euclides and Medeiros (2005), cattle supplementation is important for beef farming because it enables the increase of animal weight and, in finishing cattle, it allows for fat establishment on the carcass, which is required by slaughterhouses. Additionally, in predominant grazing systems, it helps to overcome pasture constraints during the dry season. Given this is considered the main production bottleneck for Brazilian farms, supplementation during the dry season is strategic for farmers producing young animals. This type of supplementation was, therefore, selected for further analysis. There are various types of supplements for the dry season. The protein-salt complex was chosen because it is considered effective, with a favourable cost-benefit ratio and is reasonably popular among farmers.

The selection of the cost of beef production for the case study was due to the gap between researchers and farmers regarding the importance of this technology. While researchers claim this technology is necessary for farmers to make informed decisions on the farm business, it has been historically neglected by most Brazilian farmers. Some scholars even claim that the low average performance of Brazilian beef systems is attributable to this lack of attention to cost analysis (Cezar *et al.*, 2004).

Given this research involves innovative beef farmers, adopters of this technology were expected to be found, providing the necessary contrast (i.e., non-adopters) to elucidate the rationale behind the behaviour. Improving the understanding of farmers' own views on this issue would help to clarify the debate and find solutions.

5.4.3 Data collection

The selected farmers were initially contacted by letter (Appendix D) explaining the study purpose, followed by a phone call to schedule the meetings with those that could and accepted to participate. A pilot test with one farmer was carried out in order to adjust the interview guide, measure the time demand and review any issue of concern. For instance, dubious statements for the Q-methodology were rewritten and the preformatted order of inquiry, proposed at the project stage, was abandoned to allow farmers to discuss the topics of interest at their own pace. More importantly, the Rep-Grid software, recommended for the elicitation of constructs (i.e., as per Personal Constructs Theory), was dropped from this study because the pilot test, and other four subsequent farmers, indicated it was too confusing and time consuming, with the outcomes being a repetition of what had been obtained by other qualitative methods (i.e. in depth interviews).

Data were collected in two stages. From October/2008 to January/2009, the researcher travelled around 5,000 km in *Mato Grosso do Sul* State interviewing 26 innovative beef farmers. In July/2010, eight additional farmers were interviewed in *Campo Grande*, the capital city of *Mato Grosso do Sul* State. In the first stage of data collection, the interviews took place on the farms, eventually being finished at a later stage in the farmers' office or house in town. Data were collected through in-depth face-to-face interviews with the main decision maker, following an interview guide (Appendix E). This guide included semi-structured (e.g., Ethnographic Decision Models) and structured (i.e., technological profile) methods of inquiry. All the interviews were recorded and, on the average, took 3.5 hours, ranging from 2 to 6 hours. When signs of tiredness were clear, the interview stopped, to restart later after a break or a meal.

Besides the direct inquiries, the interview also included a visit around the farm to allow for the observation of the beef production systems and, in particular, the technologies being adopted. Several pictures were taken with a digital camera in order to create an image bank for each farm. Inconsistencies between farmers' claims and the observed reality were noted, and discussed with these farmers so that any misunderstanding was resolved accordingly. With this purpose, field notes were taken to facilitate the access to information during the interview. Following the premises of the Grounded Theory, these field notes were also used to register the researcher's comments of, and insights on, particular issues noticed during the interviews (e.g., tiredness, the presence of a consultant or a recurrent theme emerging from the interview), which may have influenced the responses.

During the second stage of data collection, the eight additional farmers were interviewed in their office or house in town. There was no need to visit the farm at this stage because the objective of this second data collection was specifically to enhance the decision tree models rather than determining their technological profile or sorting statements. Consequently, a reduced form of the interview guide, presented in Appendix E, was used (i.e., excluded technological profile and the sorting of statements). The interviews took, on average, 1 hour.

All participant farmers were given a publication from EMBRAPA Beef Cattle at the end of the interview as a demonstration of gratitude for their time and effort. Additionally, one copy of the Gerenpec ®, a piece of software for planning the beef enterprise, was drawn among the farmers.

In addition to the overall procedure for data collection, described above, specific research methods using particular techniques for gathering data were employed, as explained next.

5.4.3.1 Ethnographic Decision Tree Modelling

The gathering of data to support the models on farmers' decision making followed the procedures recommended by Gladwin (1989) and principles of ethnography and phenomenology. In order to elicit innovative farmers' decision criteria and map out the decision-making process, semi-ethnographic interviews were undertaken. Farmers were asked several direct simple questions (e.g., “why do you do this?”) and invited to explain contrasting adoption behaviours (e.g., “why do you supplement cattle during the dry season but not during the rainy season?”).

At all times, care was taken to avoid leading questions, that is, questions that induce the interviewee to give expected answers. One strategy to get the interviewee relaxed and encouraged to talk freely was to show genuine interest in what the farmer had to say, reinforcing that the researcher was there to learn and not to judge. Some farmers were less eloquent than others; these often needed to be prompted. Sometimes the subject matter arose naturally during the discussion; sometimes it had to be brought into the conversation by the researcher. This was particularly noticed for the cost analysis. Most farmers had to be prompted to start, and often to keep, talking about this technology while, for the cattle supplementation, they enthusiastically provided detailed accounts.

5.4.3.2 Q-methodology

Initially, a brief explanation was given to farmers about the objectives of sorting statements (Q-sorting). Next, participants were given cards with the 49 statements, printed in large font size, on farmers’ values and goals. Then, they were asked to rapidly sort statements in three piles: (1) statements they agreed with; (2) statements they disagreed with; and (3) statements they were indifferent to. In the following step, farmers were asked to choose the four statements they most agreed with (from pile 1) and those they most disagreed with (from pile 2). These statements were placed at the extremes of a ‘pyramidal’ frame. The remaining statements were sorted according to farmers’ level of agreement, disagreement or indifference, filling the ‘data pyramid’ (for an example, see Appendix F). Farmers were encouraged to change statements as often as they wanted to until they were satisfied with the sorting.

In general, the statements sorting went well. Some difficulties were noticed, though, among some older farmers, who often asked for clarification on particular statements. Statements containing negative sentences (e.g., I do not intend to expand the business) were particularly confusing for some farmers. In order to facilitate farmers’ interpretation and sorting of statements, they were asked to read them aloud when placing the statements in the ‘pyramid’. This helped farmers to identify themselves misplaced items and, sometimes, the researcher to find inconsistencies between sorted statements and information given previously, during the qualitative inquiry.

Another difficulty was observed when some farmers formed disproportionate piles of statements, during the rapid assessment phase. These farmers found it hard to move statements from one pile to another. In this case, they were encouraged to first check for misplaced statements and second, move statements they slightly (dis) agreed with towards the central columns of the pyramid, i.e., by searching for elements in the statement that could downgrade it. Although this may have introduced some bias to the sorting, it can be argued that the blurry distinction among statements in the centre of the pyramid, spanning slight agreement, indifference and slight disagreement, does not affect significantly the final Q-sort. This is due to the difference in the relative weights of statements: those in the central area of the ‘pyramid’ have lower weights than those in the extremes, which ultimately determine the factors (or types) in Q-methodology.

After sorting the statements, farmers were invited to explain statements they most agreed and disagreed with. Any inconsistency with other sources of information was discussed and clarified, to ensure statements were placed ‘correctly’. Farmers were also encouraged to comment on any other statement they felt like, which some did. Sometimes, statements prompted parallel discussions on themes of interest to this research, supporting the gathering of data pertinent to other areas of inquiry. This opportunity was taken so that the interview could flow naturally, almost informally. On average, the Q-sorting took 1 hour (ranged from 0:45 minutes to 1:35 h).

5.4.4 Data processing and analysis

The qualitative nature of this research resulted in a large quantity of raw material for analysis. Thus, the overall processing and analysis of data comprised data reduction, coding, memo-writing, organisation under themes and reanalysis, as recommended by the Grounded Theory (Charmaz, 2006; Glaser & Strauss, 1967). Processing and analysis started as soon as the interviews finished, with a research diary being daily filled (memo-writing) with a summary of the farm system, the first insights on the farmer’s main decision criteria and a draft of the decision tree models for cattle supplementation and cost analysis. Any observation thought to be relevant was registered in this diary. These notes provided some useful insights, which were compared and contrasted with subsequent interviewees. The notes were not prepared, however, for all farmers due to the researcher’s tight travel schedule.

Once all farmers from the first stage were interviewed, data was reduced to relevant information, transcribed and translated to English. Through constant cross-case comparisons, emerging themes from the transcripts were coded, particularly those related to technology adoption. Several decision criteria for adoption and non-adoption of technologies were identified and coded, with some examples being implementation cost, ease of use and workforce demand. Additionally, descriptions of the farm and the farmers were developed, including the farmer's history and background, the beef farming system, the farm management, the farmer's social engagement and sources of information.

Data interpretation was based upon multiple sources of information (i.e., triangulation of data), including the field notes, the research diary, the photographs and the individual files with transcribed data. Additionally, patterns emerging from cross-case analysis were registered (memo-writing) for the development of theories in a later stage.

Besides this general framework for data processing and analysis, some specific procedures were required for particular types of data, which are presented next.

5.4.4.1 Quantitative data

Despite the prevalence of qualitative data, some quantitative data were also collected in this study, including farmers' socio-demographics, some farm characteristics (e.g., area), prices and technology adoption rates. In order to process and analyse this type of data, descriptive statistics were used. In particular, measures of central tendency, dispersion and location involving the 26 innovative beef farmers as a whole or in subgroups were determined using SPSS (SPSS, 2010). This statistical package, developed for social sciences, has a 'user friendly' interface, offers several statistical treatments to variables of interest and allows for exchange of files generated by other software, such as Excel. In this study, all databases were developed in Excel, being stored in spreadsheets which were then exported to SPSS for statistical treatment.

Inferential statistics were used in the particular case of adoption data in order to test whether farmers with different objectives adopt different types of technologies. However, the small sample size limited the extrapolation of results.

5.4.4.2 Decision criteria for model building

After data were collected for the 26 innovative beef farmers, the decision tree models on cattle supplementation and cost analysis were built for each farmer using the direct method. In this method, decision criteria were mapped out and plotted in a treelike model that represented the decision path of an individual farmer. Later, individual models of the 26 farmers were combined into a composite model. The construction of the composite models followed the overall premises of EDTM, although it does not specify the steps on how to build a model. As Gladwin (1989, p. 40) claimed, the researcher should juggle decision criteria until the point the tree makes sense. This process was repeated several times for the decision models on both technologies until useful models to explain the farmers' rationale were developed.

Once the composite decision models were built, a second round of data was collected to further enhance the models. At this stage, an indirect method of model building was undertaken, that is, the decision criteria of the original 26 farmers were applied to the subsequent interviewees and the fit was checked. In other words, the composite models were used as frameworks of inquiry for the eight additional innovative farmers (i.e., guided the content of questions). If the model explained these additional farmers' decisions, no action was taken; if not, then decision criteria in the composite model were reviewed and new criteria elicited (Gladwin, 1989, p. 33). The interviews of the eight innovative farmers provided empirical data for some theoretical paths, i.e., taken by none of the 26 farmers, in the composite models.

The decision tree models on cattle supplementation and cost analysis were interpreted separately and then compared so that emerging adoption patterns were analysed holistically. More details on how results were interpreted are provided in Chapter 8.

5.4.4.3 Data on farmers' goals and values (Q-methodology)

The Q-sorts (arrays of 49 statements) of the 26 farmers were entered into PQMethod (version 2.11)[10] software. The raw scores of statements varied from - 4 to + 4, with + 4 meaning strong agreement and - 4 strong disagreement; scores around zero meant that the statement was not applicable to the farmer or he was indifferent to it. The software correlated all Q-sorts and ran Principal Components Analysis (QPCA) to extract eight unrotated factors. To decide the number of factors to rotate, several criteria can be employed. The most common, according to Brown (1980), is to extract factors that have *eigenvalues*[11] higher than 1.00. Another criterion is to include all factors which have two or more significant loadings in the unrotated factor matrix (Brown, 1980; Mckeown & Thomas, 1988). The significance limit is established using the formula recommended by McKeown and Thomas (1988, p. 50): 2.58 SE (standard error), where $SE = 1/\sqrt{n}$. Given the number of statements, *n*, was 49, loadings in excess of +/- 0.3686 were all statistically significant at 0.01 level.

Based on the *eigenvalue* criterion, six factors could have been extracted for rotation. However, analysing this solution, the sixth factor had only one significant loading and one of

[10] PQMethod is a MS-DOS programme that has been adapted and maintained by Peter Schmolck (Peter.Schmolck@unibw-muenchen.de). Freeware copies of this software can be obtained and downloaded at http://www.lrz-muenchen.de/~schmolck/qmethod/downpqx.htm

[11] An *eigenvalue* is the sum of squared loadings for a factor (Brown, 1980, p. 51).

two significant loadings on factor five was very close to the limit of significance. This fact raised concerns about the significance of this loading. Further analyses were then undertaken in order to establish an appropriate number of factors for rotation.

Rotations with three, four and five factors were undertaken and the results compared (Table 5.1). From a statistical perspective, any of the three rotations could potentially represent farmers' major goals and values. The rotation of five factors presented the highest explained variance (h^2 = 68%) as a result of a greater number of factors. However, this solution resulted in more multiple loaders (7) and high correlation coefficients among three of the five factors (factors 1 x 5: 0.67; factors 4 x 5: 0.62; factors 1 x 4: 0.55). The 3 and 4-factors rotation had similar outcomes for most parameters. Both presented high level of significant loadings on factors (77%), explaining from 58% to 62% of the total variance. Additionally, the number of multiple loaders was the same for both solutions.

Table 5.1 Statistical parameters of rotations with three, four and five factors

Parameters	3-factors	4-factors	5-factors
Significant loadings/factor	11-3-6	9-2-4-5	3-2-3-4-7
Total significant loadings (% of total)	20 (77%)	20 (77%)	19 (73%)
Explained variance (h^2)	58%	62%	68%
Number of multiple loaders	6	6	7
Number of no-loaders	-	-	-
Number of factors highly correlated (>0.50)	1	2	3
Number of consensus statements	20	9	10

The statistical analysis was inconclusive in determining the ideal number of factors for rotation, justifying, therefore, a follow up theoretical analysis. The use of theoretical analysis is supported by McKeown and Thomas (1988), who argue that pure statistical analysis can lead to a tendency to overlook some factors and mislead factor interpretation. For instance, in this study, factor two would have been discarded based on statistical parameters only. However, an analysis across the 3, 4 and 5-factor solutions showed this factor was present in all of them, and had the same subjects (farmers 2 and 16) loading onto it. This indicates that these farmers' views were consistently different from the other farmers, even though they were the minority. Since one of the objectives of this study is to map farmers' diverse viewpoints (as opposed to determining their proportion in the population), the permanence of factor two is justifiable.

Based on this objective, the theoretical analysis proceeded and the *pros* and *cons* of each rotation were evaluated. This analysis suggested the 3-factor rotation was not the most compatible option to the research objectives. Despite increasing the significant loadings on each factor, limiting the solution to three factors would result in a poor scenario for exploration of farmers' goals as they would be pushed towards convergent views. This is confirmed by the higher number of statements under consensus (20 out of 49) in the 3-factor rotation, compared to 4 and 5-factor solutions. The 3-factor solution was discarded.

Following the same logic, the 5-factor rotation was apparently a more appropriate solution as it represented a wider range of farmers' major goals, in contrast to the 3-factor solution. However, analysing the factors correlation, it was observed that factor five was highly correlated to factors one and four, indicating that these factors were somewhat similar. The analysis of discriminant statements giving rise to factors one, four and five confirmed the similarity (only statement 48, i.e., I want to maintain some involvement in the farm, even after retirement, was different). The 5-factor solution was also discarded.

In contrast with 3 and 5-factor rotations, the rotation of four factors resulted in an appropriate solution for further investigation with the main parameters (explained variance and correlated factors) having intermediary results, compared to other solutions. The theoretical analysis of all four factors also showed somewhat distinctive views among farmers, supporting the choice of the 4-factor solution.

Once the number of factors was determined, the four factors were subject to Varimax rotation performed by the PQMethod software. These factors were based on 20 (77 percent) of the 26 subjects and accounted for 62 percent of the total variance. Six subjects loaded significantly on more than one factor (multiple loaders) and thus did not contribute to explain any particular factor. No further rotation was undertaken since the research objective of identifying patterns among farmers' goals and values was met. The final distribution of farmers into factors is shown below (Table 5.2).

Table 5.2 Distribution of farmers loading significantly on each factor

Factor 01	**Factor 02**	**Factor 03**	**Factor 04**	**Multiple Loaders**
Farmer 05	Farmer 02	Farmer 12	Farmer 01	Farmer 19
Farmer 07	Farmer 16	Farmer 14	Farmer 03	Farmer 20
Farmer 08		Farmer 15	Farmer 04	Farmer 21
Farmer 10		Farmer 22	Farmer 06	Farmer 23
Farmer 11			Farmer 09	Farmer 24
Farmer 13				Farmer 25
Farmer 17				
Farmer 18				
Farmer 26				
9 farmers	2 farmers	4 farmers	5 farmers	6 farmers

The factor interpretation proceeded on the basis of factor scores, which were computed as normalised Z-scores by the PQMethod software. The analysis of statements with high scores, both positive and negative, defined the prevailing views of farmers loading significantly on that particular factor. Using an abductive logic[12], theories were developed to explain particular sorting of statements within factors. The researcher, on the best of his/her knowledge, tried tentatively to provide the most likely explanation for statements' arrays, *per se*. Qualitative data (e.g., farmers' quotes) analysis followed to support and further refine the findings, acknowledging though that individual farmers within a factor do not necessarily have exactly the same views. In the light of new data, enhanced explanations were developed until satisfactory accounts of farmers' goals and values were reached.

5.5 Methodological Limitations

The Q methodology, as mentioned earlier, does not provide the proportions of ideal types (i.e., discourses) in the population like the R-method. However, this limitation is not of concern to this research, in which the aim is to explore the diverse worldviews that may exist on farmers' values and goals.

Additionally, this method may result in some subjects loading significantly on more than one factor (multiple loading) or on none of the factors (indeterminateness). The former is argued by Fairweather (1990) to be a result of an idiosyncratic Q-sort while the latter may happen because of non-distinctive Q-sort. Both situations cannot be avoided as they emerge from data and are not method-specific (i.e., they may occur in cluster and in R-factor analysis). According to Fairweather and Keating (1990), indeterminateness can be mitigated by evaluating these subjects using triangulation of data and methods (e.g., structured interview) so that these subjects' rationale can be better assessed and comprehended. In contrast, multiple loaders, whose views are spread across different factors, have their views made explicit to some extent by these factors. Thus, they require no further analysis.

Another methodological limitation, now related to the Ethnographic Decision Tree Modelling, is that the model is a snapshot of a decision. Although it has loops and 'unless conditions' allowing for a certain dynamism within the process of deciding, it does not incorporate the results of farmers' learning processes. For 'stable farming systems', this may not be as relevant as for developing farms. In the latter case, the pace of learning is greater and decision

[12] This is distinctive from deductive logic, which would start with the analysis of farmers' quotes (qualitative data) to formulate hypothesis. This procedure, however, could lead to some confusion for the factor interpretation since farmers within a factor do not have necessarily the same views.

criteria evolve more rapidly than in stable farms. This affects the validity of the results in the long term.

Because ethnographic decision tree models are deterministic in the outcomes (i.e., 'adopt' or 'not adopt'), the models do not capture the intensity of adoption. Consequently, assumptions have to be made *a priori* as to what is the minimum level that determines adoption. Also, EDTM lacks on the psychological explanations as to why particular constructs (or decision criteria) are chosen by a given group of people (Fairweather & Campbell, 1996; Murray-Prior, 1998). For instance, workload may be a relevant construct for several farmers, though for different reasons: the farmer is old; s/he has health problems; s/he has off-farm activities; and s/he wants to have more leisure time among others.

5.6 Ethical Considerations

This study was submitted to and approved by the Human Ethics Committee of Lincoln University to ensure all steps were taken to follow ethically sound procedures. Some ethical issues considered were:

- farmers' right to decline participating in this study was assured;
- confidentiality was assured to all participants, who were referred to as case numbers in the reports;
- details that could reveal respondents' identity were omitted in this report;
- farmers were asked for written consent to have interview recorded but were granted the right to stop the voice recording at any time during the interview or to withdraw any part of the interview within the subsequent week;
- interviews were conducted respectfully to respondents' opinions and integrity;
- being aware that farming is a male domain in Brazil, the researcher (a female) took additional care to approach the participants in a way that they felt comfortable while focused on the interview; and
- farmers were granted the right to have access to and benefit from the results of this study.

5.7 Summary and Conclusions

In this chapter, the philosophical and methodological frameworks have been presented and their implications considered. The constructivist-interpretivist approach overarching this study was discussed and its various theoretical orientations were emphasised, including Soft Systems Thinking, Grounded Theory, the Theory of Real Life Choice and the Personal Constructs Theory. These theories provide the guidelines upon which specific methods are selected. These methods were the Ethnographic Decision Tree Modelling (EDTM), the Q-methodology as well as some descriptive statistics. EDTM was used for gaining insights on the decision making processes of innovative beef farmers, whereas Q-methodology provides their accounts on values and goals that may influence decisions. Descriptive statistics will be used to characterise farmers and farms as well as their technological profiles (i.e., technology adoption rates).

A case study of 26 Brazilian innovative beef farmers is the research strategy and includes the analysis of these farmers' adoption of 45 technologies, encompassing the production, environmental and managerial types.

In the next three chapters, the findings resulting from this research framework are presented and discussed in depth. Specifically, the farmers' major goals and values are identified and described in Chapter 6. The role of these goals as determinants of technology adoption is considered in Chapter 7 along with other factors determining adoption decisions. In Chapter 8, a case study with two contrasting technologies is undertaken and farmers' decision making processes modelled to deepen the insights provided in previous chapters.

Chapter 6
Goals and Values of Brazilian Innovative Beef Farmers

6.1 Introduction

The first research question (Is there diversity of major goals and values amongst Brazilian innovative beef farmers, and if so, how can this diversity be characterised?) is addressed in this chapter. Q-methodology (described in detail in Chapter 5) was used and the four factors representing farmers' major goals and values are presented and discussed.

Initially, the chapter contains a description of the main socio-demographic characteristics of the 26 innovative beef farmers in order to provide context for their prevailing goals and values. Subsequently, these goals and values are identified using the Q-sort results and an analysis of the interview transcripts. Furthermore, descriptive statistics are sometimes used to support the interpretation. As part of the interpretation, attention is first given to the views shared by all types of innovative farmers. Next, distinctive views are synthesised. The results presented at that point are particularly important since the research objective being addressed here is to characterise the diversity of goals amongst these innovative farmers. This chapter also includes the discussion of results, with emphasis on the possible implications for technology adoption. Some hypotheses on the farmer types' adoption behaviour are formulated to be later investigated in Chapter 7 through the analysis of the farmers' technological profile. Other implications of the findings to theory and to stakeholders will be discussed in Chapter 9, along with the results from other components of this research. Chapter 6 finishes with a summary of the main findings on goals and values, and some concluding remarks.

6.2 A Description of Brazilian Innovative Beef Farmers

During the interviews, data were collected on farmers' socio-demographics, farm characteristics and farming systems. Descriptive statistics are presented both in aggregate and for factors in Appendix G, followed by a qualitative description of individual farmers (cases). The main aggregate results for the 26 innovative beef farmers and their farming systems are described in this section.

On average, the interviewed farmers had around 20 years of beef farming experience. A typical farmer was a well-educated male in his 50s, married, with two children (various ages). Some 73% of these farmers had completed tertiary education, of whom 63% had agricultural-related degrees and 21% had degrees in business administration. Generally, the farmers lived in town with their family and usually visited the farm once a week. The average farm was 2,784 ha with 1,749 ha of pasture and 2,540 cattle. '*Nelore*' (*Bos indicus*) was the prevailing breed (92% of farms), although 15% of farmers raised *Brangus* and several also had crossbreeds (particularly with Angus). The average farm employed six permanent people and some temporary workers during peak times (weaning and vaccination), or for particular jobs (e.g., fencing). On average, 74% of these farmers' total income was from farming (and 26% from off-farm business), with beef farming by itself providing US$757,340 of annual gross revenue.

The majority of farmers inherited their farms (54%) while others bought land (42%) or leased it (4%). Off-farm activities were undertaken by 46% of the farmers, who were usually self-employed or a business owner. Some farmers had beef farming as their only farm activity (31%) while others had on-farm diversification, particularly sheep (27%) and commercial crops (23%). The main commercial crops were soybeans and corn, particularly under crop-cattle integrated systems (CCIS), although some cotton was also found. Other farmers produced crops only for animal feed (e.g., corn for silage). Some dairy farming (15%) was also undertaken but, similarly to sheep, it was mainly for self-consumption. Around 23% ran purebred studs along with their commercial herd. The most common production system (65%) was the complete cycle, encompassing the cow/calf, rearing and finishing phases. Combined rearing and finishing, but without breeding, was also an important production system (23%), with exclusive cow/calf (8%) and exclusive finishing systems being less frequent (4%). The average age of cattle at slaughter ranged between 20 and 36 months.

While the above characteristics mostly described a 'typical' farmer in the sample, diversity was also found among some of these farmers' and farm characteristics. Farmers' ages ranged from 28 to 75 years and there was a mix of retired (35%) and non-retired farmers (from their off-farm activities). Moreover, farmers had from three to 45 years of farming experience. Thus, these innovative farmers were spread in a continuum when it comes to their stage in the life cycle, with some at the entry stage, the majority at the development stage and some at the exit stage. Farm and herd sizes also varied considerably, with farms ranging between 162 and 19,200 ha and herds between 300 and 13,980 head. This large range of farm and herd sizes was a consequence of stratified random sampling, which purposively selected small, medium and large herds (which correlate to farm sizes) for this study.

Assuming these farmers were indeed innovative, the diversity among farms and farmers' characteristics indicated that innovativeness was not limited to physical boundaries as it happened across different farm settings. Additionally, given the difference in farm settings and in innovative farmers' characteristics, it is likely that these farmers also had diverse goals. The next section (Section 6.3) covers this topic by specifically identifying these goals and establishing whether they are diverse.

6.3 Brazilian Innovative Beef Farmers' Goals and Values

In the next two sub-sections, major similar and contrasting goals and values of Brazilian innovative beef farmers are discussed. The sorting of statements by innovative farmers (Q-sorts) provided the framework upon which factor interpretation was developed. The scores of statements are interpreted using primarily an abductive logic, discussed in Chapter 5. As a convention, scores ranging from zero to (+/-) 0.25 are interpreted as neutral (i.e., farmers were indifferent to). Other scores indicate farmers' agreement or disagreement with the statements, if the sign is positive or negative, respectively. The magnitude of the score reflects the extent of farmers' (dis) agreement with a particular statement; the higher the magnitude, the more he (dis) agrees. This magnitude is graded as slight (0.26 to 0.75), moderate (0.76 to 1.25) or high (1.26 or higher). A complete list of statements with respective scores within factors is provided in Appendix H.

Farmers' transcripts, which were taken independently from the interpretation of arrays of statements, are analysed to refine and validate factor interpretation. Results are reported here, along with some illustrative quotes from farmers. Relevant results from the descriptive data (Appendix G) are also considered in order to characterise each factor. Despite the small number of farmers within the factors, limiting standard statistical tests, these descriptive data provided some additional insights into the factors.

6.3.1 Similarities among innovative beef farmers

Similarities among farmers were assessed by the analysis of consensus statements. These are statements sorted in a similar way by the interviewees represented by the four factors identified in Chapter 5, which received similar normalised Z-scores. The normalised Z-scores of consensus statements (nine out of 49) are shown in Table 6.1. Based on these scores, statements are ordered in the table from the most agreed to the most disagreed by the majority of factors. The interpretation of the consensus statements, however, does not follow the same order since related statements are discussed together irrespective of their relative position in the table. The result of the consensus analysis showed some common goals and values that this group of farmers, as a whole, held.

Table 6.1 Normalised Z-scores of consensus statements

No.	Statement	Factors 1	2	3	4
17.	My goal is to improve pasture productivity and animal performance	1.27	0.87	1.08	0.72
8.	The benefit from the security and liquidity of cattle ownership is important to me	1.16	0.50	1.11	0.53
4.	A good farm manager has control over his/her farm and is not at the mercy of outside forces	0.35	-0.19	0.42	0.51
42.	The good farmer does not exaggerate: moderate yields, modest improvements and old equipment suit me fine	-0.53	0.25	-0.21	-0.07
24.	I intend to have a higher withdrawal to live comfortably in the present	-0.45	-0.25	0.22	-0.05
6.	I always wait for other farmers to adopt new technologies before I do it myself	-0.59	-0.37	-0.70	-0.91
49.	I want to rest and enjoy retirement – it's time for kids to take over the family farm	-1.22	-0.56	-0.78	-1.29
28.	I do not have control over input and output prices, so I have to accept what the market imposes and there is nothing I can do	-1.15	-0.87	-1.08	-0.49
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.47	-1.98	-1.92	-1.94

In general, these innovative beef farmers agreed that improving pasture productivity and animal performance (statement 17) was an important goal, to a greater or lesser extent. They tended to reject the idea of being always followers of other farmers who adopt new technologies (statement 6). This suggested that sometimes they were early adopters of technology, which was consistent with the fact that farmers had been selected as being innovative. They somewhat agreed that an important benefit of owning cattle was the security and liquidity the herd provides (statement 8). This was an important cue of these farmers' attitude to risk, which may influence their adoption behaviour. Since almost half of these farmers had off-farm activities and some had on-farm diversification, it is possible that beef production was seen as a 'savings account', backing up other activities.

Most farmers tended to believe they had control over the farm (statement 4), except farmers in factor two. The relative importance of this statement, however, was not strong, possibly because they acknowledged the farm was somewhat subject to outside forces or because statement 4 might have seemed vague to them. When the idea of control over the farm was more specific, like in statement 28, their position became clearer: they moderately disagreed with having no control over input and output prices and therefore having to accept what the market dictates. Presumably, these farmers were not passive to the external environment and would try to put strategies in place to overcome market forces. The fact that most of them were members of the Association of Producers of Young Steers (APYS) was evidence of this.

Despite most farmers' indifference to statement 42, the negative sign in three out of four factors indicated that, in general, they tended to slightly disagree with modest goals and were somewhat ambitious. Given they wanted to improve the farm performance (statement 17), a possible explanation for such low scores for statement 42 was that farmers might have reacted to the expression 'old equipment'. Having 'old equipment' might have pushed farmers towards neutrality since beef farmers usually do not have as much machinery as crop producers, which was noted during the visit to the farms and mentioned by farmers. Perhaps, if these terms had been removed from statement 42, the level of rejection could have been higher to properly reflect these farmers' ambitions.

Statement 24 was also quite unimportant to all farmers. This implied they did not intend to draw significant levels of cash from the farming operation at that moment. This goal was probably facilitated by the fact that many farmers had an off-farm business to complement their income. On average, some 26% of total income was from non-farming sources. Additionally, most of these farmers were in the development stage of the life cycle, as suggested by descriptive data (Appendix G). Consequently, they were likely to be keen on further developing the farm (i.e., expanding it) to ensure a better life in the future (Olson, 2003, pp. 496-497).

Although all farmers disagreed with the idea of handing the farm over and enjoying retirement (statement 49), the reasons for disagreeing might have differed among different types of farmers. For those farmers who were not retired, disagreement showed that the statement did not suit their condition (i.e., not retired), particularly if they had no children or had young children. For those with adult children, irrespective of the farmer's retirement status, it was possible their children might have decided to follow a non-farm career and had no intention to take the farm over. Alternatively, some of these farmers disagreed with statement 49 simply because they did not want to stop farming.

Farmers also disagreed with statement 43. By strongly disagreeing with this statement, farmers were indicating they believed there was compatibility between cattle production and nature conservation. Presumably, they assumed there are sustainable ways of handling both.

In summary, this group of Brazilian farmers aimed at improving the farm technically, but subject to nature conservation. To achieve such a goal they were on occasions in the forefront of technology adoption. Moreover, these farmers seemed to look beyond the farm gate since they were not completely passive to market forces. Controlling the farm and, to some extent, controlling input and output prices were tasks these farmers were willing to put into practice in order to succeed financially, and possibly to manage risk.

Some risk preferences were signalled by these farmers when they agreed more or less that cattle provide a secure and liquid investment. This was an indication that these farmers enjoyed the low risk attached to beef production, which did not necessarily mean they were risk-averters. Depending on their willingness to take risks, on and off-diversification might appeal to them to a greater or lesser extent. For those farmers who already had a diversified farm, the security and the liquidity of cattle were possibly seen as a way to back up their income.

The fact that all farmers strongly disagreed with the idea that there is no compatibility between beef cattle production and nature conservation indicated these farmers were aware of, and sensitive to, environmental issues. Such a strong disagreement, however, might have also been motivated by the intent to please the researcher with ‘politically correct answers’. In other words, it is possible that farmers felt uncomfortable about giving a low score to an environmental statement since they were likely to be aware of world-wide criticism around the impact of farming on the environment. Another cue that this might have happened was the absence of other environmental related statements in the consensus table (Table 6.1).

Apart from statement 49, it seemed there was no consensus among farmers regarding family issues, as there were no other family-related statements in Table 6.1. This and other issues that distinguished innovative beef farmers’ viewpoints will be discussed next.

6.3.2 Factor interpretation and transcript analysis

This sub-section describes the four factors found to be relevant in the context of innovative beef farmers’ goals and values in Brazil. Each factor related to a particular viewpoint manifested by a hypothetical person (i.e., type of farmer). Each ‘person’ (or factor) was labelled based on the factor remarkable characteristics as: the Professional Farmer; the Committed Environmentalist; the Profit Maximiser; and the Aspirant Top Farmer for factors one, two, three and four, respectively.

The characteristics for factor interpretation became evident through the analysis of top-ranked and distinguishing statements. Top-ranked statements were selected on the basis of Z-scores greater than +/-1.00 (+/-2 to +/-4 raw scores) from a list of all statements, provided by PQMethod software (for procedure details, see McKeown & Thomas, 1988). Some top-ranked statements were simultaneously distinguishing statements for a particular factor and are in bold in the tables. All distinguishing statements (at 5 and 1% significance) provided by PQMethod software were analysed. Throughout factor interpretation, statements representing similar themes were grouped together for discussion and may have a different order when compared to the tables. Explanations were provided for particular arrays of statements in each factor, using abductive logic, discussed in Chapter 5 (Section 5.4.4.3).

In addition to sorting statements, farmers provided comments on particularly high scored statements. The analysis of their comments (transcripts) follows the interpretation of each factor to allow for further insights into the factor. Through comparative analyses of the farmers' transcripts, emergent themes among farmers within a factor became evident and were later compared to the interpretation of this factor, further developing the explanations. Some farmers' quotes are reported to highlight or reinforce farmers' views. Words in brackets serve to make explicit comments that farmers only implied, to fill incomplete sentences or make the sentence clear (e.g., problems with translation). Repetitive or idiosyncratic quotes are not reproduced in this section to avoid prolixity and confusion, respectively. The hypothetical farmer is often referred to as 'he' since there was no female in the original sample.

Factor one: the Professional Farmer

Farmers loading significantly on factor one (nine out of 26) had a set of objectives and values compatible with a 'Professional Farmer' (Table 6.2). The ideal farmer represented by factor one was business oriented, and managing the farm professionally was an overall goal he was committed to. He focused on sound management practices, as indicated by his strong agreement with statement 10: his goal was to run the farm as a business with clear goals and close attention to the cash flow position. He acknowledged the importance of the staff to produce high quality products (statement 14) and of having well defined roles so that the farm could run smoothly (statement 26). Additionally, he believed managerial tasks were as important to his business as the technical performance (statement 11), suggesting he sought to balance both, which was further evidence of this farmer's business orientation to farming.

This farmer's commitment to run the farm in a professional way, as a business, was evidence to support the label description as 'Professional Farmer'. Despite the fact that all types of innovative beef farmers in this study aimed to run the farm as a business (statement 10, Appendix H), this was the most remarkable characteristic of the Professional Farmer (Table 6.2) whereas farmers in other factors had other prevailing characteristics. Not only was this farmer farming in a 'professional' way but being a farmer was his main profession. Most farmers in factor one had no off-farm businesses and they were making their life out of farming. This further supported this farmer's label of 'Professional Farmer'. Other characteristics described elsewhere in this section also reinforced this label.

Although this person might have inherited the farm, he strongly disagreed that he was farming to follow family tradition (statement 32). Neither was he farming at the farm capacity to avoid land invasion by landless people[13] (statement 1). Instead, he tried to work productively because his goal was to improve the farm (statement 19).

Table 6.2 Top-ranked statements for the Professional Farmer

No.	Statement*	Average Z-Scores
10.	**My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position**	2.22
19.	My objective is to hand over the farm to the next generation in better condition than when I got it	1.85
14.	I value my staff – they are fundamental for the quality of my production	1.72
33.	**My aim is to encourage our children to study and then let them decide if they want to go farming**	1.65
5.	My objective is to adopt new technology as much as possible	1.30
17.	My goal is to improve pasture productivity and animal performance	1.27
13.	My goal is to have the best quality of livestock and pasture possible – good husbandry is the key to business success	1.23
8.	The benefit from the security and liquidity of cattle ownership is important to me	1.16
26.	My goal is to have well defined roles and activities so that the farm runs smoothly	1.10
18.	**I do not intend to expand the business**	-1.06
28.	I do not have control over input and output prices; so I have to accept what the market imposes and there is nothing I can do	-1.15
20.	The diversification of activities is not important to my farm	-1.16
1.	**My goal is to work at the farm capacity to avoid land invasion**	-1.17
11.	The technical performance is more important to the business success than the financial control and planning	-1.17
49.	I want to rest and enjoy retirement – it's time for kids to take over the family farm	-1.22
21.	**I am a beef farmer because of the freedom of being my own boss**	-1.26
31.	I intend to encourage the next generation to do something else rather than farming	-1.36
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.47
22.	**I try to make decisions on my own – I like things my way**	-1.69
32.	I farm to follow the family tradition	-1.77

* Distinguishing statements are in bold

He was seriously committed to handing over the farm to the next generation in better condition than when he got it (statement 19). Setting this as an important objective implied that this farmer constantly sought improvements, particularly in terms of productivity (statement 17). His goal of having the best pasture and livestock possible (statement 13) also

[13] In Brazil, landless people usually focus on unproductive land to invade and settle in.

exemplified his commitment to improving the farm. To achieve such priorities, this type of farmer tried to adopt new technologies as much as possible (statement 5).

For this farmer, themes like the security provided by the herd, diversification and expansion were important, as suggested by his moderate agreement with statements 8, 20 and 18, respectively. Controlling marketing when possible was also important to this farmer, who believed he played a role in the input and output prices and therefore did not have to accept what the market imposed (statement 28). Presumably, this farmer intended to expand and diversify the farm but subject to his cash availability and assessment of risk, since security and liquidity were relevant to him. Such an approach linked back to this farmer's aim of paying attention to the cash flow position, justifying his attempt to control input and output prices.

Regarding family issues, the Professional Farmer aimed to encourage his children to study and decide if they wanted to go farming (statement 33). If they did want to become farmers, he was unlikely to encourage his children to do something else (statement 31). These attitudes suggested this farmer was open-minded regarding the children's future and would not impose his own expectations on them. Since these farmers did not farm to follow family tradition and were tertiary educated, encouraging their children to study was possibly seen as a natural path for the next generation.

Farm succession, however, was a theme the Professional Farmer was not so enthusiastic about, as he moderately disagreed with the idea of resting and handing the farm over to his children (statement 49). Despite 56% of farmers in this factor being officially retired from their off-farm activities (Appendix G), clearly the Professional Farmer was active, passionate about farming and had no intention of stopping farming. High income dependence (93%) on farming might have been another motivation to keep him farming, since78% of farmers in this factor had no off-farm activities (Appendix G).

The Professional Farmer strongly disagreed that he tried to make decisions on his own because he liked things his way (statement 22). This suggested that this farmer involved 'important others' in his decision making. Since he highly valued his staff (statement 14) it is reasonable to assume they were some of these 'important others'. Being open to others' opinions reinforced the claim of the Professional Farmer as an open-minded person. Also, he strongly disagreed with the idea of being a beef farmer because of the freedom of being his own boss (statement 21).

Regarding environmental issues, the Professional Farmer strongly disagreed with the idea that to improve cattle production one needs to damage the environment (statement 43). This implied he possibly sought a balance between nature and cattle, while pursuing his goals of improving the farm and handing it over in better condition than when he got it (statement 19). Nevertheless, his lowest score to statement 43, compared to other types of farmers (Table 6.1), was an indication that he acknowledged there are some tradeoffs between environmental conservation and beef production.

Some particular views distinguished the Professional Farmer from other innovative farmers (in factors two, three and four). These views were represented by his distinguishing statements (Table 6.3). Given some distinguishing statements are simultaneously top-ranked statements (Table 6.2), and have been already discussed, more emphasis is given to other distinguishing statements.

Table 6.3 Distinguishing statements for the Professional Farmer

		Factors			
No.	Statement	1	2	3	4
10.	My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position	2.22	1.36	1.45	1.58
33.	My aim is to encourage our children to study and then let them decide if they want to go farming	1.65**	-0.93	0.59	0.07
48.	I want to maintain some involvement in the farm, even after retirement	0.73	-0.19	0.05	-0.38
15.	My priority is to improve animal welfare	0.64	1.55	-0.14	0.04
7.	I want to achieve the maximum profit feasible	0.00**	-1.05	2.67	0.79
18.	I do not intend to expand the business	-1.06	0.43	-0.48	-1.77
1.	My goal is to work at the farm capacity to avoid land invasion	-1.17	1.18	0.21	-1.70
21.	I am a beef farmer because of the freedom of being my own boss	-1.26	0.93	-0.49	-0.58
22.	I try to make decisions on my own – I like things my way	-1.69	1.42	-0.96	-0.84

**Significant at P<0.01; remaining scores are significant at P<0.05.

Compared to other farmers' values, the Professional Farmer was possibly the most open of all farmers to a participatory approach to decision making, as indicated by his strong disagreement with statement 22 (Table 6.3). Additionally, he was the only farmer who wanted to maintain his involvement in the farm, even after retirement (statement 48), which supported the claim he was passionate about farming. Another significant difference between this farmer and others was his strong interest in encouraging the next generation to study and decide if they want to go farming (statement 33).

The Professional Farmer also had different views regarding animal welfare (statement 15). He acknowledged there was still some room for further refinements of animal welfare, as he slightly agreed with statement 15. However, it was not a high priority to this farmer as it was for farmers in factor two. His view was also in contrast with farmers in factors three and four, who were quite indifferent to improving animal welfare.

All types of farmers (factor one to factor four) were business-oriented, but running the farm as a business (statement 10) was relatively more important to the Professional Farmer. This was consistent with this person's array of top-ranked statements, which privileged business related issues, as already discussed. He wanted to expand the business (statement 18) but not as much as farmers in factor four. This could have been a consequence of the age difference between these two types of farmers: the Professional Farmer was in his 60s whereas farmers in factor four were in their 40s (Appendix G). The diverse response to statement 18 may also stem from these farmers' understanding of 'business expansion': given their stage in the life cycle, it is possible the Professional Farmer was interpreting business expansion as productivity increase (consistent with his goals) while farmers in factor four were likely to think about land acquisition (i.e., increase in net worth) as a synonym for expansion.

Although there was some consensus among innovative beef farmers towards business orientation, farmers' assessment of profits was remarkably different. While the Professional Farmer was indifferent to achieving the maximum profit feasible (statement 7), farmers in factor three were highly profit-oriented and those in factor four were moderately sympathetic to profit maximisation. In contrast, farmers in factor two rejected the idea of achieving the maximum profit feasible. The diverse response to profit maximisation was a consequence of their perceptions on issues underlying this goal; in the specific case of the Professional Farmer, his zero score to profit maximisation meant this was not his major driver, despite acknowledging profit is important to the farm business. This view was a remarkable difference among innovative farmers and will be further discussed in the context of other factors.

Transcript analysis for factor one: the farm as a business

The central theme emerging from transcripts of farmers in factor one was the 'farm as a business'. This meant the farm was seen as a commercial company and was operated accordingly. In general, the 'farm as a business' required attention to organisation, planning, production and finances. In this environment, technical performance was valued as much as the managerial side of the business.

> *[Managerial performance] is as important as [technical performance] (…) farmers focus only on technology and forget about financial control and planning (...)[and this] is a constraint to the Brazilian beef sector. (F26)*

In other words, farmers in factor one valued technical issues whilst acknowledging the staff, the produce commercialisation and the cash flow control were equally important to the farm performance. Farmer 26, for instance, explained why controlling the cash flow was important:

> *Controlling the cash flow is essential. In beef farming, you get income few months of the year while the expenditures happen everyday [which] makes it harder to manage the finances. (F26)*

A result of the cash flow control was that these farmers had an understanding of price fluctuations, and, were able to better organise the commercialisation process. Therefore, they put strategies in place to monitor sales and get cheaper prices for inputs.

> *I can hold on to cattle to get better prices and I can concentrate the slaughter in the second semester because prices are higher. (F05)*

> *(...) if mineralised salt has the price increased I change brands. (F08)*

Although these farmers were financially aware and sought profit, they were neither seeking 'maximum' profit nor profit at any cost. This suggests they were socially responsible and, possibly, environmentally bounded, as farmers 08 and 26 illustrate:

> *Profit is not the main objective (...) it is important but not at any cost (F08)*

> *It's not my intention [to maximise profit]. (F26)*

For these farmers, staff were very important. Since they had the most diversified farms, they also had the largest average number of employees (Appendix G). This had implications for personnel organisation and partially justified why having well defined roles for employees was also very important to these farmers. Furthermore, most of the farmers in factor one did not live on the farm and had to rely on their staff.

> *The sculptor is more important than the sculpture: without the former, you don't have the latter. (F08)*

> *To value staff is important for me because I can't be here every day so I need to give them directions and trust they will do the job properly. (F17)*

There was a high commitment among these farmers to improve the farm. In their view, by improving the farm they were expanding the business. The scope for improvement involved environmental, social, financial and production aspects, as described by farmer 18:

> *Expansion here means in all senses: socially, economically, financially, technically. (F18)*

To achieve the aim of improving the farm, these farmers adopted technology as much as possible. However, they were more likely to be early adopters of technology rather than pioneers. They would rather observe the technology elsewhere before adopting it themselves. In doing so, they reduced uncertainties associated with new technologies.

> *You have to adopt as much technology as possible in order to achieve objective 10 [that is, run the farm as a business] (...) we are for sure early adopters, particularly compared to the majority of farmers in this region (...) [but] there is no point in being the first [to adopt technology] because you are going to pay for the onus. (F05)*

As most of these farmers had no off-farm income, they highly valued the security and liquidity, and thus the low risk involved in cattle production. This view reinforced these farmers' careful approach to technology adoption, as mentioned before.

> *It's safe [to produce cattle] (...) most cattle producers don't have loans and no matter if the price goes up or down (...) cattle is there. (F08)*

> *Cattle are my savings account. (F10)*

> *[About security and liquidity] It is important for me because I'm making my living out of this [farming]. (F13)*

In order to run the 'farm as a business', these farmers maintained an open attitude towards decision making, involving other people in this process. Whether 'other people' included staff was not clear through farmers' transcripts, although implied by farmer 18. His comment on participative decision making as a way of engaging people implied he was referring to his employees since other people would not get engaged, even if participating in the decision. It was unlikely that family members were involved in farming decisions since they were usually not integrated into farming.

> *I like to share ideas before making decisions. (F13)*

> *If I don't listen to others' opinions how can I get them engaged? (F18)*

These farmers were passionate about farming and farm work. Their motivation for farming was primarily their love for the activity and not because of family tradition. Also, they rejected any idea of being a farmer for the sake of vanity. 'Being their own boss' sounded selfish and arrogant to these farmers, as illustrated by farmer 18, who asserted *"this is arrogance"*.

> *[About being his own boss] I don't like this connotation [of vanity] (...) it is just not me. (F10)*

I think that even if I had no family tradition I would be working with farming anyway because I really like it. (F17)

Because these farmers were passionate about farming, their expectation was to continue farming. This implied that preparing for farm succession was an issue they were unwilling to handle at that time, even though they were in their 60's.

Part of my farm I will hand over to my children in few years time. The other part I'll keep to myself and my wife until I die old. (F07)

Running the 'farm as a business' meant being sensitive to environmental issues, including nature conservation. Farmers in factor one believed there was compatibility between nature conservation and beef cattle production as they agreed that animal production relies on nature. In general, they were aware that damaging the environment will decrease production and income. However, they acknowledged some level of damage was inevitable.

If we go against nature we'll run out of income later (...) if we destroy nature we destroy ourselves with it. (F11)

I think it is possible [to conserve nature and produce cattle simultaneously] according to my view of conservation because there are people out there that are too radical and think that to cut one tree is a crime. (F26)

Conclusions for factor one: in general, the transcript analysis of farmers supported and refined the interpretation of factor one and the 'farm as a business'. The Professional Farmer was farm business-oriented and focused on sound management practices in order to run the farm in a professional way. He was committed to improve the farm and to adopt technologies. His management style, however, differed from other farmers as he sought to balance farm operations with administrative and marketing tasks. This is why he aimed at improving the farm technically and, at the same time, paying attention to the finances, staff and the business structure (e.g., roles, hierarchy and goals), which was confirmed by the transcript analysis. Despite his business-orientation and belief that every business is for profit, the Professional Farmer made it clear he was not willing to maximise, or make profit at any cost. This meant he was indifferent to [making] 'maximum profit feasible'. This view was confirmed by these farmers' comments.

Clearly, he operated at the farm gate level. This means he was essentially a farmer and was less likely to diversify to off-farm activities. Being farm-oriented suggested he was likely to adopt a conservative approach when it comes to 'beyond-the-gate' issues. Such a claim was supported by the absence of statements related to debt and risk-taking, for instance, among this person’s top-ranked and distinguishing statements. Since most of these farmers were making their living out of farming, they possibly could not afford high risk. This justified having cattle as a secure activity and liquid asset, as indicated in the transcript analysis.

Compatibility between cattle production and nature conservation was also confirmed. Additionally, they acknowledged production systems inevitable impact on nature. Their aim was to reduce this impact to a minimum.

The absence of family-related statements in this person’s objectives and values suggested the farm was managed separately from family issues. This was why the ‘farm as a business’ had such an appeal to this farmer. It also justified this farmer’s aim of encouraging children to study and decide their career path. The farm was his business, but not necessarily his children’s, should they choose another path. These views were confirmed by the farmers’ transcripts.

The array of statements suggested, and the transcripts confirmed, the Professional Farmer was passionate about farming and open to ‘important others’ when making decisions. His technology adoption decisions, therefore, are also likely to be influenced by these ‘important others’. However, the claim that staff were possibly ‘important others’ in factor one interpretation was only implied by one farmer’s comment and could not be confirmed. Nonetheless, it remains a possibility since these farmers valued staff. Understanding the social interaction of the Professional Farmer with others is, therefore, crucial to gaining insights into his decisions.

Another interpretation of factor one that was not confirmed in the transcripts analysis was that these farmers did not want to stop farming because the farm was their only source of income. Although this is also a reasonable possibility, it was clear they wanted to keep active and working mainly because they were passionate about farming.

Factor two: the Committed Environmentalist

Two farmers out of 26 loaded significantly on factor two, which personified the views of the ‘Committed Environmentalist’. This person’s 17 top-ranked and 14 distinguishing statements are shown in Tables 6.4 and 6.5, respectively.

Table 6.4 Top-ranked statements for the Committed Environmentalist

No.	Statement*	Average Z-scores
41.	**Nature conservation is important and I value it as much as my income goals**	2.23
45.	**I really appreciate the outdoor life, close to nature and with animals around**	1.61
15.	**My priority is to improve animal welfare**	1.55
22.	**I try to make decisions on my own – I like things my way**	1.42
10.	My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position	1.36
13.	My goal is to have the best quality of livestock and pasture possible – good husbandry is the key to business success	1.36
19.	My objective is to hand over the farm to the next generation in better condition than when I got it	1.30
1.	**My goal is to work at the farm capacity to avoid land invasion**	1.18
27.	I try to control the sales of my production because I want to insure I receive the best return possible for my products	1.11
47.	I like innovating because new challenges inspire me	1.05
7.	**I want to achieve the maximum profit feasible**	-1.05
5.	**My objective is to adopt new technology as much as possible**	-1.11
20.	The diversification of activities is not important to my farm	-1.61
9.	**My objective is to increase the crop production**	-1.61
38.	**Business goals must take priority over household needs**	-1.80
11.	The technical performance is more important to the business success than the financial control and planning	-1.80
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.98

* Distinguishing statements are in bold

The Committed Environmentalist valued nature conservation as much as his income goals (statement 41). He appreciated the outdoor life, being close to nature and having animals around (statement 45). His priority was to improve animal welfare (statement 15). Despite his commitment to nature, he strongly believed beef cattle production and nature conservation were compatible and there was no need to improve one at the expense of the other (statement 43). Presumably, this person believed there were sustainable ways of producing cattle and conserving the environment at the same time. His focus on environmental goals was evidence for the label 'Environmentalist'. Wilkes and Krebs (1988, p. 374) define an environmentalist as a *"specialist in the **maintenance of ecological balance** and the **conservation of the environment**"*.

The Committed Environmentalist appeared to be self-centred as suggested by his strong agreement with statement 22 about making decisions on his own. Possibly, his views on production and environment were unlikely to be shared by other types of farmers, who might not fully accept the environmentalist's values and motivations. This gap might have made this person more sceptical about other people's viewpoints and tried to do things his way.

Being a Committed Environmentalist did not mean this farmer was less careful about the business itself. He aimed at running the farm as a business, with clear goals and close attention to his cash flow position (statement 10) like other types of farmers. Although he did not want to maximise profits (statement 7), he tried to control sales to ensure the best return possible to his produce (statement 27), which supported his goal of running the farm as a business. From a technical standpoint, he believed good husbandry was the key to the business success and, thus, set the goal of having the best quality of livestock and pasture possible (statement 13). In addition to technical goals, he acknowledged the role of managerial tasks for the business success, as he strongly disagreed with statement 11.

This farmer wanted to utilise the full capacity of the farm to avoid land invasion by landless people (statement 1), unlike other farmers. This person's concerns about land invasion might stem from his focus on environment conservation rather than production, possibly making room for landless people to claim any 'unproductive land'. Additionally, his farm could have been invaded in the past, or is located close to a conflict zone.

On-farm diversification was very important to the Committed Environmentalist's business (statement 20), which was supported by the fact that both farmers in factor two had other farming enterprises, including an ecological tourism operation in one case (farmer 02, as shown in Appendix G). Diversification was possibly a way to diversify his sources of income and reduce income fluctuation while allowing for the pursuit of his environmental goals. However, options for diversification were likely to be limited to those with a low environmental impact. Some evidence was his rejection to the idea of increasing crop production (statement 9). Presumably, the higher requirements for chemicals and for tree clearance to allow for mechanisation did not fit into this person's environmental values.

Another important objective for this person was to hand over the farm to the next generation in better condition than when he got it (statement 19). Apparently, 'condition' in this farmer's view referred mainly to environmental aspects. This claim was supported by the lack of production-related topics in this person's top-ranked statements, which, in turn, suggested increasing production was not his major goal. This farmer's moderate disagreement with statement 5, that is, he did not have as an objective to adopt new technology as much as possible, reinforced his lack of orientation towards maximising production.

Not having a keen interest in adopting technology was apparently contradictory to this farmer's agreement with statement 47 (I like innovating because new challenges inspire me). Presumably, the Committed Environmentalist's understanding of being innovative was not limited to adopting new technologies; possibly, he interpreted being innovative as doing things differently from conventional farmers. Pursuing environmental goals while producing beef was possibly seen as innovative, justifying his agreement with statement 47.

Household needs were also very important to the Committed Environmentalist since he strongly rejected the idea that business goals must take priority over household needs (statement 38). This suggested that he would sacrifice farm goals to some extent to pursue some of his family's needs. His higher score for environmental and family goals (statements 43, 41, 45, 15 and 38) than for business goals (statements 10, 13, 27 and 7) indicated the business goals had the lowest priority. The lack of production-oriented statements in the top list also reinforced this. These aspects suggested the Committed Environmentalist held, to a large extent, non-tangible motivations for farming.

Besides the core statements representing the Committed Environmentalist's viewpoint, some unique features distinguished this farmer from other types of farmers (Table 6.5). He was the only type of farmer who strongly valued nature conservation goals as much as income goals (statement 41), which reinforced his high commitment to the environment. Unlike other farmers, the Committed Environmentalist wanted to maximise neither the beef production (statement 16) nor the profits (statement 7). Rather, his priority was to improve animal welfare (statement 15), which reinforced the idea that this person's motivation was more related to intangible benefits. Presumably, he accepted lower cash returns in order to pursue his environmental goals. This set of characteristics illustrated his high commitment to the environment, and, was evidence to justify the label description as *'Committed'*.

Table 6.5 Distinguishing statements for the Committed Environmentalist

		Factors			
No.	Statement	1	2	3	4
41.	Nature conservation is important and I value it as much as my income goals	0.89	2.23	0.16	1.22
45.	I really appreciate the outdoor life, close to nature and with animals around	0.54	1.61**	-0.16	0.26
15.	My priority is to improve animal welfare	0.64	1.55	-0.14	0.04
22.	I try to make decisions on my own – I like things my way	-1.69	1.42**	-0.96	-0.84
1.	My goal is to work at the farm capacity to avoid land invasion	-1.17	1.18	0.21	-1.70
21.	I am a beef farmer because of the freedom of being my own boss	-1.26	0.93**	-0.49	-0.58
32.	I farm to follow the family tradition	-1.77	0.68**	-1.51	-1.26
18.	I do not intend to expand the business	-1.06	0.43	-0.48	-1.77
16.	I want to maximise the beef production in my farm	0.81	-0.87**	1.38	1.94
33.	My aim is to encourage our children to study and then let them decide if they want to go farming	1.65	-0.93	0.59	0.07
7.	I want to achieve the maximum profit feasible	0.00	-1.05**	2.67	0.79
5.	My objective is to adopt new technology as much as possible	1.30	-1.11**	0.57	1.26
9.	My objective is to increase the crop production	0.20	-1.61	-0.65	-0.07
38.	Business goals must take priority over household needs	-0.54	-1.80	-0.73	-0.86

**Significant at P<0.01; remaining scores are significant at P<0.05.

The Committed Environmentalist really appreciated the outdoor life, being close to nature and having animals around (statement 45) whereas other farmers were less sensitive or even indifferent to the countryside qualities. It follows from his strong agreement with statement 45 that the Committed Environmentalist found most joy in the farm lifestyle.

All the other farmer types seemed to be more open-minded than the Committed Environmentalist, who tried to make decisions on his own (statement 22). Unlike those types, the Committed Environmentalist was a beef farmer because of the freedom of being his own boss (statement 21). These characteristics reinforced the claim he was more self-centred than other types of farmers. His moderate disagreement with the idea of encouraging his children to study and decide if they want to go farming (statement 33) might be further evidence for his self-centred character. Since he was the only farmer who farmed somewhat to follow family tradition (statement 32), it is reasonable to assume he wanted to maintain the family tradition and, therefore, keep children farming. Alternatively, his disagreement with statement 33 might have reflected the fact this farmer's children were adults and pursued non-farming careers, in which case the statement did not represent his family objectives.

As the top ranked statements indicated, the Committed Environmentalist put emphasis on other goals rather than production and business ones. This characteristic was unique to this farmer type as suggested by his distinguishing statements (Table 6.5). For example, he strongly believed household needs must take priority over business goals (statement 38). His moderate disagreement with statements 16, 7 and 5 and his agreement with statement 18 also illustrate his different priorities compared to other farmers: he was the only farmer who did not want to maximise either beef production or profits, did not intend to expand the business and was not interested in adopting new technologies as much as possible.

In addition, by strongly disagreeing with statement 9, this farmer was indicating he was unlikely to increase crop production, even though on-farm diversification was important to him (statement 20, Table 6.4). In contrast, other types of farmers were more dubious or slightly negative about crop production, suggesting they were not keen on crop production but neither were they strongly against it.

Transcript analysis of factor two: the sustainable production

'Sustainable production' was the emergent theme for factor two. The farm under a sustainable framework focused on long-term results rather than immediate 'misleading' outcomes. Farmers in factor two were interested in managing in cooperation with nature since they believed animal production was compatible with nature conservation. Farmers of a ‘sustainable’ farm were passionate about nature, animals and farming. This was a precondition to maintain a ‘sustainable production’ approach.

> *I like trees, I love to hear the birds singing and I like cattle. (F02)*

> *I lived all my life surrounded by animals (...) I’m passionate about beef cattle. (F16)*

An indication of these farmers’ concerns with sustainable production was their willingness to improve animal welfare conditions. Taking good care of animals was not only an objective but usually a value these farmers held.

> *(...) people from ‘Organic Beef’ [Association] taught we can’t prod cattle. Here we have no dogs to run after cattle and rope is forbidden (...) My grandad already had this concept of taking good care of animals. (F02)*

Because these farmers sought sustainability and believed this was the best approach to farming, they wanted to be a model for other farmers. They certainly believed they played a role in making other farmers aware of alternative ways of raising cattle and conserving nature at the same time.

> *I hold a value of being a good example for other farmers to follow (...) but it’s not in the sense of vanity or showing off (...) we have to think about the next generation. (F02)*

They also enjoyed being in charge of their own lives and tried to do things their way.

> *I do everything on a trial-error basis (...) I’m a bit of an inventor. (F02)*

> *I enjoy being in charge of my life (...) I like things my way indeed [and] I make decisions by myself. (F16)*

A sustainable way of production often meant being committed to long-term results. These farmers believed that balancing production and nature conservation would yield better outcomes in the long run.

> *In the long run, you are going to make more money if you hold this value [of cattle being compatible with nature]. We need to have more sustainable ways of production. (F02)*

> *Nature conservation is important and if I had this view earlier I wouldn’t have deforested as much as I did. (F16)*

Focusing on long-term results suggested these farmers would accept more modest physical and financial performance at present in order to use, and benefit from, natural resources longer. Their views on production and profit maximisation provide some confirmation of this:

> *Maximum production doesn't mean it's going to benefit you because you might be destroying the environment (...) If we focus on profit maximisation, we end up having problems (...) the world cannot afford this model [of production and profit maximisation]. (F02)*

Being against profit maximisation did not mean these farmers did not seek financial sustainability. Like other farmer types, these farmers were also proactive and tried to influence input and output prices. They acknowledged, however, their influence was limited.

> *I have little control but I can influence these prices (...) I am reducing mineralised salt and I know my productivity will fall a bit (...) suppliers cannot increase prices so significantly overnight [so] the price is going to fall soon. (F02)*
>
> *(...) being a member of the Association [of Producers of Young Steers] is a way of getting better prices for my produce. (F02)*

When it comes to technical issues, these farmers took a cautious approach. Given the risks associated with technology adoption, they were not so enthusiastic about adopting new technologies as much as possible. In order to manage the risk of adoption, these farmers experimented with, or observed, technology first. This risk behaviour was to some extent related to their age:

> *I like to test it [technology] in small scale first to reduce the risk. (F02)*
>
> *Nowadays I'm not very much interested [in technology adoption] anymore because of my age (...) I don't like to be a pioneer and I like to check on others first. (F16)*

Regarding the possibility of working at the farm's capacity to avoid land invasion these farmers were quite vague and provided no clear evidence this was an objective. Rather, they expressed their political views on the issue, as farmer 16 illustrates:

> *It's not common in this region but it happens out there and I don't agree. (F16)*

Household needs were very important to these farmers and when it comes to priorities: *"family needs come first"* (F16). The fact that family was not integrated into the farm business implied that family decisions were made irrespective of the farm. Children, for instance, had opportunities to choose their career path, including non-agricultural professions.

> *I don't have [family working on the farm] (...) [My children] studied and decided on their career. (F16)*

Conclusions for factor two: the transcript analysis of farmers in factor two was challenging since only two farmers were involved. The task of compiling the views on some topics was particularly difficult when only one farmer talked about an issue or when farmers had slightly different opinions. In this case, preference was given to farmer 2's comments since he was more strongly associated with factor two than farmer 16, as indicated by their significant loadings into this factor (i.e., 0.75 for farmer 2 versus 0.62 for farmer 16). Although this limitation is acknowledged, it does not render this analysis unimportant, since it provided additional insights into these farmers' thinking.

Transcripts from the farmers mostly fitted the foregoing interpretations for this factor, particularly with regard to environmental aspects. The farmers' focus on sustainability was evident throughout their interviews, confirming the label of a Committed Environmentalist. Furthermore, their scepticism regarding any sort of profit or production maximisation was also confirmed. In particular, the lack of comments on production-related issues reinforced the argument these farmers were more enthusiastic about achieving their environmental goals than their production ones.

Farmers in factor two, in general, valued non-tangible benefits and put their environmental and family goals first; sometimes at the expense of their business goals, as the statements indicated and the transcripts confirmed. They also expressed their love for nature and animals, which justified their values related to animal welfare. The importance of social and environmental issues to these farmers suggest, when it comes to make business decisions, the solution must fit these values. It seems that the Committed Environmentalist would not hesitate to sacrifice some business goals, should his family face difficulties in meeting its needs.

From a production standpoint, factor interpretation and transcript analysis implied technology that harmed nature was unlikely to be adopted. The transcripts refined this idea adding these farmers' risk behaviour as an element considered in technology adoption decisions. Moreover, it seems the Committed Environmentalist focused on long-term sustainability rather than immediate results. Consequently, he emphasised the benefits to the entire ecological system instead of solely beef production, when making decisions.

Because of all these unique views, the Committed Environmentalist appeared to be more self-centred than other types of farmers, making decisions on his own. This was further refined by the transcripts analysis, which showed that being innovative, enjoying experimenting with different approaches and creating technologies themselves (i.e., ‘inventor’) led the two farmers to do things their way, and thus, to make decisions on their own. The transcript analysis also revealed that being self-centred was not the reason for disagreeing with encouraging children to study, as suggested in the factor interpretation. Rather, their disagreement was due to having grown up children who had already decided on their careers; this was also considered in the factor interpretation, and thus, confirmed.

One implication of these farmers’ self-centred characteristics may be that they were not as open to agricultural consultants as other types of farmers, unless these consultants shared some of their views. This may also have impact on their technology adoption behaviour.

Factor three: the Profit Maximiser

Four farmers loaded significantly on factor three, whose main views are shown in Table 6.6. The hypothetical farmer represented by factor three was someone concerned with his current and future income. His most important goal was to make the maximum profit feasible (statement 7).

Table 6.6 Top-ranked statements for the Profit Maximiser

No.	Statement*	Average Z-scores
7.	**I want to achieve the maximum profit feasible**	**2.67**
23.	**An important goal to me is to have enough money for a comfortable retirement**	**1.81**
13.	My goal is to have the best quality of livestock and pasture possible – good husbandry is the key to business success	1.49
10.	My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position	1.45
16.	I want to maximise the beef production in my farm	1.38
27.	I try to control the sales of my production because I want to insure I receive the best return possible for my products	1.37
14.	I value my staff – they are fundamental for the quality of my production	1.24
8.	The benefit from the security and liquidity of cattle ownership is important to me	1.11
17.	My goal is to improve pasture productivity and animal performance	1.08
25.	**My objective is to reduce my workload and improve my quality of life**	**1.06**
37.	Some people put too much emphasis on the business end of farming; for me, it is a lifestyle as much as a business	-1.00
28.	I do not have control over input and output prices; so I have to accept what the market imposes and there is nothing I can do	-1.08
39.	**For me it is important not to allow the farm rule my life**	**-1.17**
31.	I intend to encourage the next generation to do something else rather than farming	-1.21
36.	**It is important to me to be recognised as a modern farmer**	**-1.43**
32.	I farm to follow the family tradition	-1.51
40.	One virtue of farming is that you can have your family working alongside you	-1.62
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.92

* Distinguishing statements are in bold

Having enough money to retire[14] comfortably (statement 23) was also an important objective for this farmer, who was on average 52 years old (Appendix G). It seems he wanted to minimise uncertainties around the future and maintain his lifestyle by achieving the maximum profit feasible. This was corroborated by the fact that this farmer valued the security and liquidity of cattle (statement 8). Perhaps, owing cattle was seen as securing his retirement. This set of characteristics resulted in this person's label of 'Profit Maximiser', which was supported by other characteristics presented elsewhere in this section.

Other important goals and objectives for the Profit Maximiser were in line with his objective of maximising profit, as shown in Table 6.6. He wanted to have the best quality pasture and livestock possible (statement 13), to maximise the beef production (statement 16) and to improve pasture and animal productivity (statement 17). He also acknowledged the value of staff in order to produce high quality products (statement 14), and perhaps, profit. Beside these production-related objectives, being recognised as a modern farmer was not among his important goals, as indicated by his disagreement with statement 36. By disagreeing with it, this farmer was indicating he was not seeking recognition.

Reducing the workload and improving life quality (statement 25) were lifestyle goals of the Profit Maximiser. The fact that this farmer had the largest farm of all farmers, with 5,428 hectares on average (Appendix G), suggested farming demands were higher for the Profit Maximiser than for other farmers, which was supported by his acknowledgement that the farm somewhat ruled his life (statement 39). Hence, he wanted to reduce his farming workload and enjoy life.

Although he valued lifestyle goals, farming was not confounded with lifestyle *per se*. For this farmer, farming was a business and not a lifestyle (statement 37). Presumably, farming was a means to support his cosmopolitan lifestyle, which was evidenced by the fact all farmers in factor three lived in town (Appendix G). Additionally, they were indifferent to being close to animals and nature (statement 45, Appendix H) and slightly disagreed with the sense of belonging to the rural community (statement 35, Appendix H).

Consistent with the view of 'the farm as a business and not as a lifestyle' was the goal of running it as such, with clear goals and close attention to the cash flow position (statement 10). This farmer's emphasis on profits justified his attempt to control sales and ensure his products the best return possible (statement 27). In addition, by disagreeing with statement 28,

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[14] In Brazil, men retire with 65 years of age or 35 years of contribution to the government superannuation (whatever comes first) whereas women retire with 60 and 30 years of age or contribution, respectively (PortalBrasil, 2010b).

he was indicating he tried to control input and output prices to some extent, which was also consistent with his philosophy of profit maximisation.

His strong disagreement with statement 43 indicated that, although profit-oriented, this farmer was environmentally sensitive too. He believed there was compatibility between beef production and nature conservation. Possibly, he was seeking production and profit maximisation, but subject to his environmental values to some extent.

Regarding the relation between farm and family, the Profit Maximiser strongly disagreed that one virtue of farming was to have his family working alongside him (statement 40). Since the Profit Maximiser did not farm to follow family tradition (statement 32), it was plausible that he did not impose his choice on his children either, letting them choose their career path. However, as he was concerned with his retirement, and possibly succession, he did not intend to encourage the next generation to do something else rather than farming (statement 31). Presumably, he hoped his children would take the farm over when he retires.

Although some of the previous views were shared among other types of innovative farmers as well, the Profit Maximiser held some unique views. These unique viewpoints were represented by 12 statements which discriminated this farmer from other types of farmers (Table 6.7).

Table 6.7 Distinguishing statements for the Profit Maximiser

		Factors			
No.	Statement	1	2	3	4
7.	I want to achieve the maximum profit feasible	0.00	-1.05	2.67**	0.79
23.	An important goal to me is to have enough money for a comfortable retirement	-0.39	-0.25	1.81**	-0.69
25.	My objective is to reduce my workload and improve my quality of life	-0.56	-0.25	1.06**	-0.69
11.	The technical performance is more important to the business success than the financial control and planning	-1.17	-1.80	0.98**	-0.98
34.	My goal is to share farm work and farm decisions with my spouse	0.09	-0.19	0.73	-0.14
5.	My objective is to adopt new technology as much as possible	1.30	-1.11	0.57	1.26
1.	My goal is to work at the farm capacity to avoid land invasion	-1.17	1.18	0.21	-1.70
41.	Nature conservation is important and I value it as much as my income goals	0.89	2.23	0.16	1.22
20.	The diversification of activities is not important to my farm	-1.16	-1.61	-0.27**	-1.31
18.	I do not intend to expand the business	-1.06	0.43	-0.48	-1.77
39.	For me it is important not to allow the farm rule my life	-0.38	-0.25	-1.16	-0.23
36.	It is important to me to be recognised as a modern farmer	-0.46	-0.50	-1.43	1.27

**Significant at $P<0.01$; remaining scores are significant at $P<0.05$.

The Profit Maximiser was the only farmer who was concerned about having a comfortable retirement (statement 23) and whose objectives included reducing the workload and improving life quality (statement 25). He was also the only one who agreed, even though slightly, with the objective of having a higher withdrawal to live comfortably in the present (statement 24, Appendix H). These objectives reinforced the idea that this farmer was seeking to maintain or improve his lifestyle, which might justify his profit orientation. This profit orientation, however, was in sharp contrast with other types of farmers who scored from moderate negative to moderate positive for the profit maximisation statement (statement 7).

This person's way to achieve his economic goals also differed substantially from other farmers. He moderately agreed that the technical performance was more important to the business success than the financial control and planning (statement 11). His focus on technical issues was reinforced by his top-ranked goals number 13, 16 and 17 (Table 6.7). Presumably, to achieve the maximum profit feasible his farm needed to maximise beef production as well (statement 16) by means of high quality pasture and cattle (statements 13 and 17).

Although technically focused, this person was less keen on adopting new technology as much as possible (statement 5), compared to farmers in factors one and four. Given technology adoption potentially brings risks to farm profitability, the Profit Maximiser took a careful approach in taking up innovations. Therefore, he was more conservative than other types of innovative farmers, particularly those in factors one and four.

Being more conservative might have been one of the reasons for this farmer's disagreement with statement 36; perhaps, he did not see himself as a very modern farmer. Alternatively, this strong rejection of statement 36 could have been in response to 'recognition' rather than 'modern'. The rejection to 'recognition' was particularly distinctive from farmers in factor four, for whom recognition for being a modern farmer was very important.

Another remarkable difference of this farmer compared to others concerned business strategies. The Profit Maximiser was quite indifferent to on-farm diversification (statement 20) while diversification seemed to be very important to other farmers. Moreover, business expansion was another strategy this farmer was less willing to carry out when compared to other farmers, as indicated by their scores for statement 18. A possible explanation is that he already had a large farm, so expansion was less appealing to the Profit Maximiser. Additionally, farm diversification and its further expansion were both likely to increase his workload. This was an aspect this farmer was apparently unwilling to increase.

While other types of farmers were quite indifferent to statement 34 and slightly disagreed with statement 39, the Profit Maximiser scored moderately for both. He wanted to share farm work and decisions with his spouse, even though his family did not work alongside him (statement 40, Table 6.6). He possibly acknowledged farm decisions affected not only his lifestyle but also his wife's. His moderate disagreement with statement 39, in turn, indicated it was not important to prevent the farm from ruling his life. In other words, the Profit Maximiser accepted that the farm eventually ruled his life, perhaps the reason he wanted to reduce workload and improve his life quality.

There were few issues the Profit Maximiser was indifferent to while other types of farmers had stronger viewpoints. Land invasion (statement 1) was one example that he scored neutral, while other farmers held moderate to strong views, both in the positive and negative directions. Nature conservation was another issue he was indifferent to. Being neutral to statement 41 suggested he was not as committed to conservation as other farmers. Although the Profit Maximiser claimed there was compatibility between cattle production and nature conservation (statement 43, Table 6.7), it is likely that in situations where his income goals were at risk he might have prioritised cattle production over nature. Perhaps, this farmer thought it would be 'politically incorrect' to admit that his goal of maximising profit was somewhat conflicting with his environmental goals.

Transcript analysis of factor three: 'farming to make money'

A recurrent theme throughout the interviews of factor three's farmers was 'farming to make money'. These farmers not only discussed profit when referring to the profit-related statement but also constantly mentioned profit to justify their choices on other statements. Making profit was an end-goal *per se*, as farmer 22 exemplifies: *"I want the maximum profit feasible" (F.22)*. Furthermore, it was seen as a means of pursuing other objectives:

> *[I want to maximise profit] because more profit means more cash and then we live better. (F12)*
>
> *Profit allows you to do other things like: improve staff conditions, conserve my farm better etc. (...) My goal, for instance, is to obtain around R$ 700.00 of net profit/ha/year. (F15)*

Consistent with their views on making money, these farmers ran the farm as a business with close attention to the cash flow position. Despite the importance of controlling the cash flow, they were focused on the technical performance rather than on formal management. As a result, they had no sophisticated financial control and planning.

> *Cash flow is essential to any business. (...) The technical side of production, like buying well and producing better, is more important than having financial control. (F14)*

I manage the farm more intuitively because (...) what matters is the technical performance. There are excellent farms that don't have good control. (F22)

The technical performance was, therefore, seen as one way to achieve their end-goal of 'making money'. Having good pasture and cattle, they believed, supported maximum production, thus, maximum profit.

Good cattle and good genetics are also important to profit. [So, I want to maximise beef production] to have high profit. (F12)

Nonetheless, risk was an issue that might have prevented these farmers from being more progressive. In general, they only took moderate risks in order to do better.

Beef production is a low risk activity so, if I'm producing beef, it's because I don't like risk. On the other hand, I have to take risk sometimes in order to do better. (...) I don't borrow too much [money] but I don't want to be too conservative either. (F14)

Risk, along with workload, also influenced these farmers' views on farm diversification and expansion. They were unwilling to diversify the farm, particularly using crops, mainly because they believed crops are riskier and more demanding than cattle. These farmers seemed a bit more enthusiastic about the business expansion. Their understanding of business expansion related to performance improvement rather than land acquisition.

Diversification is not important (...) it means more work. (F12)

I want my business to grow particularly at this stage of life I am at now [in his 40s] (...) [After I turn 60] I have to rethink priorities. (F14)

I haven't diversified [the farm] because of risk. (F22)

These farmers' views on beef farming as a back-up activity also highlighted their risk-aversion characteristic. They enjoyed the low risk associated with beef production, which was seen as a savings account, particularly among those who had off-farm businesses.

[Security and liquidity provided by cattle] is important because I have the farm as a second activity. (...) I borrowed money from my other business to invest in beef [but] if one day I decide to do the opposite I can sell the cattle to return cash to my business. (...) This is like a savings account. (F14)

Despite a somewhat conservative approach to business, these farmers considered themselves modern, possibly as a consequence of their focus on technical performance. However, they were not seeking recognition from third parties, which was seen as vain.

It’s important to be modern to get results but not to boost your ego. (F14)

I consider myself modern (...) it’s important to do a good job for the sake of your own satisfaction. (F15)

They tried to control the produce transactions even though they acknowledged they had limited power over input and output prices. However, they put strategies in place to ensure good margins and to achieve their goal of maximising profits.

We don’t have much control over prices, but you can observe the best time to buy [inputs and] you can join the Association [of Producers of Young Steers] to get a premium for your produce. (F15)

Good staff was perceived as important to production and, by implication, to profits. These farmers, however, bore responsibilities for developing and maintaining a good team. Thus, they acknowledged they played a leadership role in managing their team.

I think they are fundamental to production (...) I try to direct them and always arrange meetings to check what they say. (F12)

It’s important to work alongside good staff [and] we have to bear responsibility here: if you have good staff it’s because you oriented them well but if you don’t, it’s your fault either because you are not orienting them properly or because they are still working for you after making no progress. (F14)

Farmers in factor three listened to other people but ultimately made decisions on their own.

I listen to others but, at the end, I end up doing [things] my way. (F15)

I try to take into account my Mom’s opinion but I don’t necessarily follow her ideas, otherwise I wouldn’t have done half of what I did. (F22)

In general, farming and family were not integrated as these farmers usually had no family farming alongside them. A consequence was that farmers’ children were encouraged to study and decide on their careers, just like their parents did.

If they [children] want to keep farming that’s their right; but if they don’t like this [farming] and decide on doing something else, that’s their personal decision. (F14)

My family never worked with me. (F15)

The pursuit of lifestyle goals was very important to these farmers, who wanted to enjoy life currently and in the future.

[Having a comfortable retirement] is important because having money means I don't need to worry too much. (F12, who was retired)

I always looked into the future and tried to have some savings (...) but always trying to live a good life meanwhile (...) to spend money is as important as to earn it. (F15)

Consistent with these farmers' lifestyle goals was their desire for reducing workload and improving life quality.

[To reduce the workload] is one of the objectives but I haven't been able to do this. (F14)

[One of] my objective[s] is definitely to improve my quality of life. (F15)

Farming, however, was not seen as a lifestyle *per se*, but as a business. Regardless of being raised on a farm or not, these farmers did not have strong attachments to farming and may stop farming if it becomes less profitable or riskier.

Beef production is not a lifestyle (...) [it] is an economic activity as any other. (F14)

I was raised on a farm (...) [but] I am farming because [it has been] a second activity [that] provides me with security, despite the low return. (F15)

My family has been farming (...) [but] if one day the beef market becomes unprofitable I may lease the farm and do something else. (F22)

Conclusions for factor three: factor three personified the values of a farmer who was seeking a reasonable income level, currently and in the future. As a result, he wanted to maximise profit and, like other innovative farmers, run the farm as a business. Transcript analysis confirmed and refined the interpretation of these farmers' orientation towards profit maximisation. Not surprisingly was the fact that the main theme for the 'Profit Maximiser' was 'farming to make money'. The farmers making up the Profit Maximiser put several strategies in place to ensure profits, as presented in the transcripts analysis. Moreover, farmers' views revealed that profit was both an end-goal, *per se*, and a means for pursuing other goals, such as comfortable retirement and life quality improvement.

The Profit Maximiser's management style was different from other types of farmers. As the farmers' comments showed, they stressed the technical performance rather than the formal management because they clearly associated maximum production with maximum profit. Consequently, these farmers appeared to manage the farm more on an intuitive basis, as most traditional Brazilian farmers do, than based on organised information, as indicated in their interviews. Additionally, farmers making up the Profit Maximiser were not as open to diversification and business expansion as the other farmers. The transcripts refined this interpretation explaining the reason was associated with perceived risk and work demand.

These farmers' risk-aversion characteristics clearly influenced their perceptions not only of diversification and expansion, but possibly of technology adoption. Although no clear evidence was found regarding the later, it is plausible that perceived risk was one reason for their careful approach to technology adoption, particularly given the role of beef farming in providing safe income to these farmers (as a 'savings account'). Despite their approach to adoption, they considered themselves modern. Nevertheless, the idea of being recognised as a modern farmer found strong rejection among them as they perceived this as being vain, as suggested in the statement analysis and confirmed in the transcript analysis.

The Profit Maximiser did not farm to follow family tradition. Neither did he impose his choice of farming on his children, who might have non-farming careers. For succession reasons, the Profit Maximiser did not discourage the next generation to go farming either. His main lifestyle objectives comprised reducing workload, improving the quality of life and ensuring a comfortable retirement, which distinguished this farmer from other farmer types. These lifestyle objectives were confirmed through farmers' transcripts and their views on 'rural' versus 'city' lifestyle were further refined.

Farmers did not emphasise environmental goals during the interviews, repeating aloud the statements and providing no further elaboration. This suggested that, although they scored statement 43 very high, they were not enthusiastic about it. There appeared to be a lack of commitment to environmental conservation when this meant a negative impact on profit.

Factor four interpretation: the Aspirant Top Farmer

Factor four comprised five out of 26 farmers, whose main views are presented in Table 6.8. Farmers loading significantly on factor four represented a hypothetical farmer whose main objectives were to maximise beef production (statement 16) and produce high quality meat (statement 29). Presumably, in this way he could achieve his other objective of being the best farmer he could be (statement 46), seeking what he sees as excellence in farming and being recognised for this. Examples were his acceptance of recognition for producing high quality meat (statement 29) and for being a modern farmer (statement 36). Accepting recognition did not necessarily mean he wanted to 'show off', but rather indicated he was concerned with his image perhaps because it was an important part of his business strategy.

The above set of characteristics justified this person's description as the 'Aspirant Top Farmer'. Other statements provided further evidence for this label and will be discussed throughout this section.

Table 6.8 Top-ranked statements for the Aspirant Top Farmer

No.	Statement*	Average Z-scores
16.	I want to maximise the beef production in my farm	1.94
29.	**I want to have my farm recognised for producing high quality meat**	**1.77**
46.	**My goal is to be the best farmer I can be**	**1.76**
10.	My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position	1.58
47.	I like innovating because new challenges inspire me	1.48
36.	**It is important to me to be recognised as a modern farmer**	**1.27**
5.	My objective is to adopt new technology as much as possible	1.25
41.	Nature conservation is important and I value it as much as my income goals	1.22
27.	I try to control the sales of my production because I want to ensure I receive the best return possible for my products	1.09
30.	**I avoid having debts – to have debts means poor administration, in my opinion**	**-1.21**
32.	I farm to follow the family tradition	-1.26
49.	I want to rest and enjoy retirement – it's time for kids to take over the family farm	-1.29
20.	The diversification of activities is not important to my farm	-1.31
1.	**My goal is to work at the farm capacity to avoid land invasion**	**-1.70**
18.	**I do not intend to expand the business**	**-1.78**
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.94

* Distinguishing statements are in bold

Although this person might have inherited the farm, he disagreed with statement 32 that he was farming to follow family tradition (Table 6.8). Neither was he farming to avoid land invasion (statement 1). In his view, the farm was a business and he wanted to run it as such, with clear goals and close attention to the cash flow position (statement 10). This was reinforced by his moderate agreement with statement 27: he wanted to ensure good sales.

The Aspirant Top Farmer was seriously committed to expand the business and to diversify the farm, as indicated by his strong negative scores for statements 18 and 20, respectively. The fact that 80% of farmers in factor four also had off-farm businesses (Appendix G) suggested his business approach to farming might have been influenced by his non-farming experiences. Moreover, pursuing these business strategies might have been facilitated by his open-minded attitude to borrowing money. By moderately disagreeing with statement 30, this farmer not only indicated he did not believe having debts was a sign of poor administration, but also signalled he was open to externally financing the farm. Thus, he was eventually a risk-taker.

This farmer's strong agreement with statement 47 indicated he was likely to innovate in order to pursue his goals of maximising beef production and achieving high quality products. His innovative character was also evident in his objective of adopting new technology as much as possible (statement 5). This progressive approach to farming, along with a strong disagreement with the idea of resting and enjoying retirement (statement 49), suggested he was at the development stage of the life cycle. Demographic data provided further evidence, as farmers in factor four were in their 40s, being the youngest of all farmers (Appendix G) and most had either no children or two young children.

On the issue of nature conservation, statement 43 showed this farmer believed there is compatibility between beef production and nature conservation. The latter was valued as much as his income goals (statement 41). This was consistent with the Aspirant Top Farmer's objective of being the best farmer he could be since damaging nature could prevent him from achieving excellence. Allegedly, his concerns were possibly not only for the environment *per se*, but also extrinsically motivated by his attempts to pursue excellence and get recognition.

Although some of this person's unique characteristics have been already discussed (above), a comparison between this farmer and other types of farmers make the distinguishing aspects clearer. Also, some subtle aspects of this person's values and objectives may arise within the comparative analysis. For this purpose, distinguishing statements are presented in Table 6.9.

Unlike other farmers, this person held a strong goal of being the best farmer he could be (statement 46). This implied he sought excellence in farming, which was confirmed by his agreement with statements 29, 36 and 7. By agreeing with statement 44, this farmer was acknowledging that his keenness for excellence was not limited to the business performance but included aesthetic aspects too. He wanted to enhance the landscape and have a beautiful farm, whereas other farmers thought this was irrelevant (statement 44).

Table 6.9 Distinguishing statements for the Aspirant Top Farmer

		Factors			
No.	Statement	1	2	3	4
29.	I want to have my farm recognised for producing high quality meat	0.71	0.87	0.44	1.77
46.	My goal is to be the best farmer I can be	-0.18	0.25	-0.46	1.75**
36.	It is important to me to be recognised as a modern farmer	-0.46	-0.50	-1.43	1.27**
7.	I want to achieve the maximum profit feasible	0.00	-1.05	2.67	0.79**
44.	I want to enhance the landscape and have a beautiful farm	-0.43	-0.43	-0.24	0.52
12.	I want to diversify my assets and invest in off-farm activities	-0.48	-0.93	-0.97	0.19
30.	I avoid having debts – to have debts means poor administration, in my opinion	-0.49	-0.06	-0.48	-1.21
1.	My goal is to work at the farm capacity to avoid land invasion	-1.17	1.18	0.21	-1.70
18.	I do not intend to expand the business	-1.06	0.43	-0.48	-1.77**

**Significant at P<0.01; remaining scores are significant at P<0.05.

Although not necessarily ostentatious, the Aspirant Top Farmer needed to demonstrate proficiency, which probably led him to seek recognition. Almost all previous distinguishing statements (Table 6.9), directly or indirectly, reinforced this, apart from statements 12 and 30. Different from other farmers, he wanted to be recognised for being modern, for producing high quality meat and, possibly, for having a beautiful farm. Such a strong need for external appreciation suggested this was important not only to himself but possibly to marketing as well. Consequently, this farmer was likely to be tuned into the wider context of farming.

The Aspirant Top Farmer also had some distinct views on business strategies. This farmer was the most committed to the farm expansion (statement 18) of all types of farmer, which was possibly justified by his young age and willingness to increase his net worth. Presumably, one way of expanding the business was by borrowing money, as discussed previously. This suggested he was more of a risk-taker than other innovative farmers. Evidence that further supported the Aspirant Top Farmer's risk-taking characteristic was his slight disagreement with restricting borrowing to a low percentage of assets (statement 2, Appendix H). Another way to finance the business expansion was possibly through reinvesting farm profits. This was why achieving the maximum profit feasible (statement 7) was moderately important to this farmer. This was in sharp contrast with other farmers' views on profits, as discussed in previous sections.

Diversifying assets and investing in off-farm activities (statement 12) did not appeal to the Aspirant Top Farmer, who was indifferent to this, possibly as a consequence of having off-farm activities already. The positive score of this statement suggested, however, that this farmer was not against off-farm investments either; although not willing, he was open to the possibility of further asset diversification, in contrast with other farmers.

Transcript analysis of factor four: challenge as a motivation

The emergent theme for factor four was 'challenge as a motivation'. Throughout the interviews farmers on factor four highlighted their taste for challenges as a motivation for farming. This enthusiasm was not limited to farming operations and affected the way the farm related to the 'external world'. As a result, these farmers were innovative when dealing with commercialisation and marketing strategies. In their view, innovation was closely related to challenges. They understood innovation as a challenge and, therefore, were keen on being innovative.

> *I like to innovate and I like new challenges. I don't feel triggered or motivated by easy things. That's why I adopt new technologies. (F01)*

I like to innovate. (...) I'm not scared of new challenges. (F04)

They believed innovations push the boundaries and this was a great motivation for these farmers. They wanted to be the best farmer they could be, and, often better than other farmers. This was perhaps the greatest challenge of all, since to be the best implied seeking excellence in a broad way. This desire for being the best also brought to light some vanity and pride aspects of these farmers' personality.

After hard times, I learned that the best I can do is to try to be the best farmer I can be. I must admit that I have vanity (...) and [want] to show others how to run a beef business. (F03)

Being the best I can be (...) makes this [farming] challenging. (F06)

In order to be the best, these farmers were willing to act differently from the majority of beef farmers and to take additional risks. Taking risks was also challenging and perceived as *"part of the business growth" (F09)*.

Anyone can see the mountain; the challenge is to see beyond the mountain. (...) You have to have expertise and be constantly analysing the external environment (...) to act differently from the market [meaning, his peers]. (F06)

Being the best farmer was only one part of these farmers' motivation. The counterpart was being recognised for it. They wanted their farms to be a model for other farmers and this was evidenced by their pride in being a good farmer.

I think recognition is cool. I always like to show the farm to other people so that they avoid doing the same mistakes we did (...) I really like to hear that my cattle are good, well finished (...) it's our merit. (F01)

This farm is known as a model. (...) It's a matter of personal and professional vanity [as] it feels good to have this recognition. (F03)

A consequence of having a model farm was that these farmers were interested in aesthetics and in having a beautiful farm. Presumably, they paid particular attention to the farm image since they were likely to have people visiting their farms frequently.

I get many people visiting us. (F01)

I know this [having a beautiful farm] has a cost but I like it beautiful, clean and organised. I feel proud of it. (F03)

I like a beautiful landscape. (F04)

In order to appear the best farmer, these farmers were ready to take new challenges and innovate. They were willing to pursue several different business strategies so that they could differentiate themselves from other farmers. On-farm and off-farm diversification were examples; both were seen as ways to secure income and, possibly, to mitigate risks. On-farm diversification was also seen as a way to use technology more efficiently.

> *[The farm] is part of my assets. [Ideally] I would have 1/3 of my assets on farm (land), 1/3 maybe on cattle as reserve of capital that is more liquid [than the farm] and 1/3 on interest. (F03)*

> *(F09) Diversification is important because you have technologies complementing each other (...) but mainly because of risk as you can combine and balance riskier activities with less risky ones, resulting in better sustainability in the long run, from production and financial standpoints.*

Expansion was another strategy these farmers were committed to. Expansion, in these farmers' view, meant intensification of current production rather than land acquisition. They believed expansion was a natural, almost inherent, path for supposedly any farm.

> *I said I like challenges and therefore I'm keen on expansion (...) but expansion for me is to improve this farm and not to buy more land. There is no point in having land but not doing a good job on it. (F01)*

A consequence of such an emphasis on improving the farm was that these farmers were keen on technology adoption. Allegedly, to be the best farmer they could be they believed they had to be up to date with modern technology. This does not mean, however, that they adopted any modern technology, but those that fitted into their production system at costs they could afford.

> *Any technology that comes to improve [the farm] is welcome. (...) Of course we need to analyse costs. (F01)*

> *Modern technology does not necessarily mean it fits into my production system. (F09)*

Although they might have been pioneers in some technologies, in general, they were likely to be more often early adopters. This means they did not necessarily wait for others farmers to adopt technology. Rather, it suggested they sought to understand technology better before adoption, possibly, because they wanted to make sure it fitted into their production system.

> *I don't wait for others. I was the first to adopt rotational pasture and people in the region criticised me a lot. (F04)*

> *I always try to understand about new technologies through reading and visiting other properties but once I'm convinced that it's good for my system, I adopt. (...) I don't wait for others. (F09)*

To achieve excellence in farming, these farmers believed several factors were important. Examples included: good pasture, improved cattle genetics, high productivity and good meat quality.

> *If you have good pasture, improved genetics and high quality meat you'll achieve success. (...) I have a small farm and it needs to be productive, meaning, more meat per hectare. (F04)*

Furthermore, they valued their personnel. These farmers acknowledged people were an essential part of the production system as they enabled other elements of the system to improve. Having well-defined roles was additionally crucial so that staff were aware of goals and tasks to be accomplished. Personnel organisation was also important because it reduced the demand for supervision. This was possibly critical to these farmers, since none lived on the farm and most had off-farm businesses as well (Appendix G).

> *Every Monday I come here and organise everyone's tasks for the week. I believe if you have a well defined organisation chart and clear roles, these people can work with minimum supervision. (F03)*

> *It's absolutely fundamental to value staff professionally and encourage them to participate if you are looking for excellence. (F09)*

These farmers, like farmers in the other factors, also wanted to run the farm as a business with close attention to the cash flow position.

> *You have to manage your farm properly (...) beside the annual budget, we review every month our tri-month budget so that I keep up with my cash flow and I can relax. (F03)*

> *[Farm finance] is another element of my production system I need to manage properly. (F06)*

Financial management and control was also seen as a feedback tool on technical performance.

> *The technical side of farming is very important but if you don't have financial control and plan things properly you never know if the technique will increase the costs rather than the results. (F04)*

> *If you have no financial control you don't even know why you are looking at the technical performance. (F09)*

Financial excellence was, by implication, also sought by these farmers, as farmer 06 justified that "*to be the best [farmer] you have to have profit"*. However, profit was not seen as a major motivation in itself, but as a natural consequence of farming with excellence.

> *Profit is not my priority. It's a consequence. (...) It's a reward for a good job. (F01)*

> *Profit is a consequence of your work. (F04)*

In seeking financial excellence, these farmers put several marketing strategies in place. All strategies required a thorough understanding of the production costs, allowing to better plan commercial strategies and channels in order to secure margins.

> *Sometimes we sell cattle at the futures exchange (...) to secure margins once you know your costs of production. (F01)*

> *We focus on selling cattle at an optimum time in terms of market conditions or when the animal gets to 480 kg of liveweight, when it breakevens [market price equals production cost]. (F03)*

Beside the use of the costs of production as part of a marketing plan, these farmers also controlled input and output prices as far as possible. Although they acknowledged they had limited control, they were not passive to market forces and believed the key was to look at 'beyond-the-gate' solutions.

> *Input and output prices are mostly established by the market but you don't have to accept that. You have to go beyond the gate. (...) You can operate at futures exchange (...) you can also join producer associations (...) or cooperatives. Last year, the cooperative I'm a member bought inputs 19% cheaper than the market price. (F09)*

Since these farmers were used to operating beyond the gate and were somewhat risk-takers, they were open to external funding to finance farm operations and growth. Thus, having debts was not seen as poor administration but as means to expand the business. They often obtained small loans either to avoid insolvency, or because of limits established by funding agencies.

> *(...) the problem [of borrowing money] is the low amount of funds available for us. (F01)*

> *To have debts is a sign you want to expand your business. If I was to use only my own capital to expand the business, nowadays I would be at the same level I was 7 years ago. (F09)*

Managing the exemplar farm with excellence required these farmers to be environmentally friendly. They acknowledged it was important to conserve nature in order to keep their farm productive in the future and to comply with legislation. Nevertheless, they were aware that environmental practices or recovery can be costly, which may prevent them from carrying on such activities.

> *I think [nature conservation] is important. (...) I'm implementing a reforestation project but I'm going to lose almost 400 hectares of productive land [to comply with legislation] (F01)*

> *If I damage nature I'm compromising the sustainability of my own business. Every activity has environmental impact, (...) so agriculture is not different [and] to minimise such an impact is perfectly compatible (...) although costly sometimes. (F09)*

Farmers in factor four, like farmers in other factors, did not integrate their family into farming. Some of these farmers had no children while some had school age children living in town, partially justifying their non-participation. They did not want to impose their expectations on their children to become farmers and would rather encourage them to study and decide themselves on their careers. The non-participation of wives and adult children was generally due to their lack of interest.

> *I don't have children. (F01)*

> *[My children] may get involved later with farming; it's completely up to them what they will do as a profession. (F03)*

> *My family doesn't come here [to the farm]. (F04)*

> *My children don't like farming. (F06)*

Conclusions for factor four: the Aspirant Top Farmer's main values and objectives were related to excellence, growth, diversification, innovation and recognition. In summary, this farmer was the most progressive of all types of farmers, which was consistent with the fact he wanted to be the best farmer he could be. He wanted to maximise beef production and improve quality through technology adoption. He was also keen on expanding and diversifying the farm, perhaps including off-farm investments. Peculiarly, he would not mind borrowing money to do so. The transcript analysis showed that farmers in factor four were very active and tuned into a wider context of farming. They focused on beyond-the-gate issues and on how they could make the most of external opportunities in order to be different, and hopefully better, than other farmers.

Through the transcripts, other interpretations of the Aspirant Top Farmer were refined. One aspect enlightened was farmers' taste for a challenge as a motivation for seeking excellence. The analysis also confirmed these farmers' need for recognition of being the best farmer and doing a good job. It highlighted aspects of farmers' vanity and pride, revealing they wanted to be a model for other farmers. Another issue that was brought to light by the transcript analysis which was not apparent in factor four interpretation was the importance of financial control and costs of production to the business strategies. Their unique view on both subjects was a major difference between farmers in other factors and those in factor four. They believed financial control allowed measuring technical performance. This suggests they used the financial results to conclude on the appropriateness of farming operations and performance. Unlike other farmers, they also focused on cost control as a tool for conscious decisions regarding their marketing strategies. These two aspects revealed these farmers made informed decisions, based on economic concepts.

In order to create a good environment for farming, farmers in factor four believed they needed to challenge and modify, when possible, the nature of markets. For this reason, these farmers were regularly talking about futures exchange, political engagement and participation in associations and cooperatives rather than talking, like other innovative farmers did, about pasture and cattle. The lack of production-related issues was not a lack of interest. Rather, it suggested these farmers might have already achieved good standards and were, at this stage, focused on marketing. The wider context of farming appeared challenging and exciting (i.e., out of their comfort zone).

Finally, views on family and environmental matters confirmed and refined the factor four interpretation that their family was not integrated into farming and that environment conservation was essential for business sustainability. The transcript analysis validated the overall factor four interpretation and corroborated the label of a ‘Aspirant Top Farmer’.

6.4 Implications of Innovative Beef Farmers’ Characteristics and Major Goals for Technology Adoption

Analysis of farmers’ Q-sorts and associated transcripts demonstrated some similar views amongst Brazilian innovative beef farmers. Despite being selected as ‘commercial *family* farms’ (as opposed to subsistence or corporate farms), these innovative farmers in general did not strongly integrate family into farming. Consequently, they disagreed, to some extent, with the idea that an advantage of farming was to have their family working alongside them (statement 40, Appendix H). The 26 farms were all managed by male farmers, with only two being helped by females (farmers’ wives). In the specific case of married farmers (88.5%), they were the main decision makers even when their wives were the legal farm owners (i.e., by inheritance). Despite the wives being invited to participate in this study, the husbands responded since they were the managers and were interviewed, therefore. The peripheral role of females on the sampled farms was illustrated by the overall insignificance of sharing decisions and farm work with their spouse (statement 34, Appendix H), other than for farmers in factor three who were moderately positive about this. Extended family, particularly their brothers and/or fathers, more often participated in farming than their wives. All the above reasons justified interviewing only male farmers, even though there were four women in the original contact list.

Although some of these farmers had a family tradition in farming and acknowledged this influenced their path, most of these innovative farmers were tertiary educated. Therefore, they shared the views of encouraging children to study and decide themselves on their careers. This view illustrated that farming was not imposed on children, but was optional. The freedom children had in choosing their careers reinforced the idea of family and farming being managed somewhat separately by these farmers.

Another obvious reason for a family not being integrated was farmers having very young, or no children. Additionally, 77% of these farmers lived in town and the family did not visit the farm often. More importantly, living in town allowed family members to develop a 'cosmopolitan' lifestyle, and consequently, a lack of interest in farming, particularly among wives and adult children. This 'cosmopolitan' lifestyle often extended to farmers themselves. The fact that almost half of these innovative farmers also had non-farm businesses provided further evidence of these farmers' connections to the urban lifestyle. Farmers' urban lifestyle might explain, to a certain extent, why these farmers generally were not enthusiastic about belonging to the rural community (statement 35, Appendix H). Farmers living in town had a foreman on the farm to organise daily activities. However, this employee had very limited decision power, as farmers were the main decision makers, as mentioned in this chapter.

Because family and farming were not integrated, farming was seen by most farmers primarily as a business and not so much as a lifestyle. As a business, these farmers' overall goal, surpassing all other goals, was to continue farming. In order to sustainably manage the farm as a business, these farmers agreed that it was important to improve the farm performance both technically and financially. Some farmers were more progressive than others, but in general they were open to new technologies, sometimes being early adopters. Similarly, they shared the view that beef production was compatible with environmental conservation.

Despite sharing some views, these Brazilian innovative farmers held many unique combinations of goals and values which distinguished them from one another, even though all of them were innovative and produced beef under similar environmental conditions (i.e., *Cerrado*). This means that managing the farm as a business had different meanings for different innovative farmers, and resulted in different approaches to farming. In this study, the major approaches, reflecting several different combinations and prioritisation of goals, were illustrated by the 'hypothetical' farmers labelled: the Professional Farmer, the Committed Environmentalist, the Profit Maximiser and the Aspirant Top Farmer. These four farmer types are likely to have significant implications for technology adoption. Other types of farmers (i.e., multiple loaders) were also identified but had their views covered, to some extent, by the previous farmer types.

Given the various goals and value systems amongst the farmer types, their willingness to adopt production, managerial and environmental technologies is likely to have varied. Although it is acknowledged that the analysis of prevailing goals is insufficient to determine these farmers' actual adoption behaviour, some hypotheses can be formulated, as argued below.

The Professional Farmer, the Profit Maximiser and the Aspirant Top Farmer (factor one, three and four respectively) were in general production-oriented and, therefore, were likely to have high adoption rates of production technologies. For the Professional Farmer and the Aspirant Top Farmer, adoption of production technologies supported their intent to improve the farm (statements 16, 17, 19 and 20), promote growth (statement 18), achieve quality (statements 13 and 29) and innovate (statements 5, 36 and 47). Additionally, by using production technology the Aspirant Top Farmer could achieve his goal of being the best farmer he could be (statement 46). In turn, the adoption of production technologies by the Profit Maximiser was possibly seen as a means of achieving the maximum profit feasible (statement 7). However, his desire to reduce the workload and to pursue lifestyle goals indicated that production technology should overcome the workload constraint to appeal to this farmer type. In contrast with the previous types, the Committed Environmentalist placed higher priority on conservation than on maximising production or profits. He wanted to run a sustainable farming system, possibly sacrificing some current production to use more environmentally friendly techniques and achieve long-term sustainability. This means that production technologies must fit this farmer's environmental values to be considered for adoption, which may limit his willingness to adopt this type of technology.

Similarly, farmers' willingness to adopt managerial technologies is likely to vary among these innovative farmers. The Profit Maximiser was likely to adopt less managerial technologies than other types of farmers since he believed the technical performance was more important than the business administration. Some further evidence that managerial technology was not so appealing to the Profit Maximiser was his low score to statement 26 (i.e., importance of having well defined roles for staff), along with farmers' claims that they were somewhat 'intuitive' (as opposed to formal controllers) in managing the farm. Despite focusing on the business profitability, it is possible the Profit Maximiser did not relate managerial technology adoption with profit increase or found this type of technology time consuming, thus failing his workload constraint.

The Professional Farmer and the Committed Environmentalist, in contrast with the Profit Maximiser, were likely to be keen on managerial technologies to pursue their goal of running the farm as a business (statement 10). This was suggested by these farmers' beliefs that managerial tasks were as important as technical performance (statement 11) as well as their attempts to control prices (statement 28) and sales to ensure the best return possible (statement 27). Their motivation for the adoption of managerial technologies might have differed. While the Professional Farmer was motivated to become an efficient farmer, which required planning and control of farm operations, the Committed Environmentalist was motivated by learning about the interaction between beef cattle and the environment. In his case, controlling was primarily a tool to assess the sustainability of production (and biological) processes, enabling the farming system to adapt and evolve. Furthermore, marketing was highly valued by the Committed Environmentalist because producing 'ecologically friendly' cattle was possibly seen as a market opportunity to differentiate his produce and get a premium price as well as explore ecological services (e.g., ecological tourism).

As suggested above, the Professional Farmer and the Committed Environmentalist were both open to managerial technologies mostly applicable to farm operations unlike the Aspirant Top Farmer, who was keen on managerial technologies with application on and off-farm. This was indicated by these farmers' operation in futures trading, participation in market alliances and use of external funds to develop the farm, all of which demanding more sophisticated managerial practices. His business-minded character might stem from his high involvement with off-farm activities. As a result, the Aspirant Top Farmer was the most progressive of all types of farmers.

Regarding the environmental technologies, production-oriented farmers were likely to be less enthusiastic, and thus have lower adoption rates, than the Committed Environmentalist. In general, all types of innovative farmers were aware of, and sensitive to, environmental issues (as implicit in statement 43). However, their commitment to environmental practices varied along with their motivation for carrying such practices as suggested by factor interpretation and transcript analysis. Not surprisingly, the Committed Environmentalist scored highly for all environmentally-related statements (e.g., 15, 41, 43 and 45) clearly suggesting he was the most willing adopter of environmental technologies. His strong environmental values indicated he held an intrinsic motivation to undertake sustainable practices.

The Aspirant Top Farmer was possibly highly keen on adoption of environmental technologies since he strongly rejected the idea that there was no compatibility between beef production and nature conservation (statement 43) and strongly maintained the latter was as important as his income goals (statement 41). However, this farmer's pursuit of his environmental goals might be more extrinsically motivated than as a result of intrinsic motivation, contrasting the Committed Environmentalist. This argument was supported by the Aspirant Top Farmer's low interest for farming settings (statement 45). Furthermore, this farmer's strive for excellence and strong interest in being a model to other farmers might have been major motivations for taking good care of nature.

The Professional Farmer was also open to environmental technologies, but possibly less than other types. Some cues of the Professional Farmer's willingness to adopt environmental technologies are that he moderately valued nature conservation as much as his income goals (statement 41) and wanted to improve animal welfare (statement 15). Nevertheless, having the lowest score to statement 43, compared to other farmers, indicated his commitment to nature conservation was possibly not as high as of other farmers. Transcript analysis confirmed this farmer believed some impact on nature was inevitable, but should be minimised. This farmer's demographics might provide justification for such a belief in that they were making their living mostly out of farming, suggesting they could not afford conservation as much as the other types. Being reliant on natural resources for family and business survival possibly made them tolerant to environmental impact.

The Profit Maximiser, in marked contrast to the other types, was somewhat puzzling over environment-related goals. Despite strongly believing that cattle production and nature conservation were compatible (statement 43), the Profit Maximiser tended to disagree with other environment-related statements (statements 15 and 45), although score magnitudes were fairly neutral. He was also neutral, though positive, about valuing nature conservation as much as his income goals. This apparent inconsistency among this farmer's goals may stem from two situations: (1) he overreacted to statement 43, as the underlying message of 'no compatibility at all between nature conservation and beef production' might have looked too radical, and therefore, he strongly disagreed; or, (2) he was trying to please the interviewer and gave a 'politically correct' answer, since he might have felt embarrassed to admit that conserving natural resources was somewhat contradictory to his goals of maximising beef production and profits. Irrespective of the reason for this ‘apparent’ inconsistency, the Profit Maximiser seemed less keen on environmental technologies than other types of innovative beef farmers given his focus on production and profit maximisation, and his overall low interest in environmental topics.

Besides the diversity of farmers’ goals and their likely impacts on the adoption of specific types of technologies, as discussed above, other distinguishing views have potential to effect technology adoption in general given their broad nature and applicability. This was the case of farmers’ views on decision making and risk as well as their innovativeness.

As mentioned earlier, decision making was mainly carried out by the farmer himself with no or little help from his immediate family. However, some farmers were open-minded and liked to listen to, or engage with, other people in making decisions, while other farmers were self-centred and made decisions on their own. The decision of self-centred farmers, like the Committed Environmentalist, was likely to rely mostly on personal judgement, observing technology on-site and testing technology himself on a small scale before wide implementation. As farmer 02 noted, *“observation is the key of this system because [the system] is based on ongoing learning of ecological processes, including cattle production”*.

Being self-centred, the Committed Environmentalist was possibly less willing to take advice, perhaps including consultants’ advice, which might be a limitation for technology adoption. This farmer’s remarkably distinct view relative to other farmers, and probably to consultants (namely, production-oriented), might have led this farmer to develop ‘his own customised farming system’.

In contrast, the other three types of innovative farmers were open-minded and aimed to share, to various extents, their decisions. This was particularly important for the Professional Farmer and the Aspirant Top Farmer, who were likely to source technological information from various people; the difference being, these various people were more farm-related in the former’s case, and farm and non-farm related people in the case of the Aspirant Top Farmer. Given the external-orientation of the latter farmer, his network was likely to be large and diverse. In terms of technology adoption, networking and open-mindedness mean these innovative farmers might have been more exposed, or exposed earlier, to innovations, increasing the chances for adoption or, more specifically, early adoption.

Farmers’ attitude to risk was another aspect that seemed to vary among these innovative farmers and may influence their willingness to adopt new technologies. In general, all types of farmers enjoyed the overall low risk associated with beef production (statement 8). Nonetheless, the Professional Farmer and the Aspirant Top Farmer were often risk-takers as they sometimes believed taking risks was necessary to succeed in business (statement 3). Yet, in the specific case of borrowing, their views were different. The Aspirant Top Farmer was the most open to externally financing farm operations (i.e., highest score to statement 30) and was not so concerned with limiting borrowing to a small proportion of assets (statement 2). The Professional Farmer, on the other hand, was a ‘conservative risk-taker’ since he was less keen on getting loans and argued these should be kept small, in comparison to total assets, should he needed to borrow money. In contrast with these two types of farmers, the Committed Environmentalist and the Profit Maximiser scored neutral for statement 3 and thus, were to some extent indifferent to taking risks. The negative score from the Profit Maximiser, though, suggested he had some slight aversion to risk, which was mentioned during his transcript analysis. Regarding borrowing, this farmer was moderately open to getting a loan (statement 30), but was indifferent to limiting the amount borrowed (statement 2). Finally, the Committed Environmentalist tended to be risk-neutral since he scored neutral to statements 3 and 30. His moderate disagreement with the idea of limiting borrowing to a small proportion of total assets (statement 2), however, might stem from his lack of production orientation, which could have resulted in financial difficulties, leading him to borrow more than he would like.

These farmers’ contrasting risk behaviour suggests they would respond differently to innovations. Their responses were reflected by statements 5, 6 and 47, which again revealed different positions among these innovative farmers. Farmers’ scores for all these statements, taken holistically, showed that the Profit Maximiser was keen on innovating and usually did not wait for other farmers to adopt technologies. However, he was less willing than the Professional Farmer and the Aspirant Top Farmer to adopt as much technology as possible (i.e., lowest positive score to statement 5) given his slight risk aversion. Since both the Professional Farmer and the Aspirant Top Farmer were risk-takers, they both strongly wanted to pursue high technology adoption; the Aspirant Top Farmer more than the Professional Farmer. At last, the Committed Environmentalist’s neutral risk behaviour gave no clue about his innovativeness. The analysis of statements 5, 6 and 47 revealed some contrasting, and apparently contradictory views, of this farmer type. He was very inspired by innovating on the farm and, at the same time, strongly rejected the goal of adopting as much technology as possible. Clearly, his understanding of ‘innovating’ (statement 47) was broader than ‘adopting technologies’. In this farmer’s view, ‘innovating’ meant doing things differently, being creative and developing technology himself, or, as farmer 02 put, being *“an inventor”*.

Therefore, farmers making up the Committed Environmentalist saw themselves as innovative because they were creative and ran unconventional farming system, and not necessarily because they adopted as much technology as possible. However, this farmer type was still open to technology adoption to pursue his farming goals (e.g., statements 13, 15 and 17) and hand over the farm in improved conditions to the next generation (statement 19). In this case, like other types of farmers, the Committed Environmentalist did not wait for other farmers before he adopted technology himself; this was a cue that he was sometimes an early adopter.

The above results showed that, in general, risk-taking farmers tended to be more open to innovating than risk-averting farmers. Results also suggested that farmers' perceptions of innovativeness had two dimensions: (1) related to being progressive; (2) related to being creative. Under these two dimensions of innovativeness, the types of beef farmers hereby analysed were more or less innovative. Being progressive was the aim of the Aspirant Top Farmer, followed by the Professional Farmer and, to a lesser extent, the Profit Maximiser. Under this 'progressive' dimension of innovativeness, the Committed Environmentalist lagged behind. Nevertheless, under the dimension of 'being creative', this farmer was possibly a leader since his innovativeness manifested principally by doing things unconventionally, following his own instincts and experimenting his creative ideas on a trial and error basis. Another creative, and therefore innovative, type of farmer was the Aspirant Top Farmer, who also strived to differentiate himself from the majority (as indicated in his transcript analysis), particularly regarding marketing. The Professional Farmer and the Profit Maximiser, eventually, were less 'innovative' under the 'creative' dimension of innovativeness, since they are likely to have a more conventional approach to farming. Besides the dimensions of innovativeness, results suggested the scope for innovating was also diverse and varied among innovative farmers. Some farmers seemed more innovative in technical issues (e.g., the Profit Maximiser), some in business administration (e.g., the Professional Farmer), some in marketing strategies (e.g., the Aspirant Top Farmer) while others were more innovative in environmental-related issues (e.g., the Committed Environmentalist).

Farmers' age was a factor possibly underlying major differences among farmers' prevailing goals, since age may reflect farmers' experience, stage of family/farm development and 'societal worldviews' as well as affects farmers' physical ability. In this study, younger farmers, like those making up the Aspirant Top Farmer, undertook a more progressive approach to farming than the other types of farmers. Given his age, and consequently stage in the life cycle, it is possible he was willing to develop the farm rapidly to increase his total net worth. The fact he was young, well educated, had a small young family and needed capital to develop the farm justified his off-farm pursuits.

If age was indeed an underlying factor, the farmer types were snapshots of different stages of farming any one farmer goes through as they get older. In other words, young farmers who are production-oriented are likely to be risk takers, similarly to the Aspirant Top Farmer (he was in his 40s). Since risky behaviour sometimes results in failure, farmers' approach to farming becomes more cautious as they get more mature and expand their families, which calls for a more responsible behaviour. This was why these farmers, like the Profit Maximiser (who was in his 50s), focused more seriously on profitability, envisaged a comfortable retirement and became more keen on lifestyle goals. When they get old and retire from off-farm businesses, they can afford to become full time farmers and concentrate on being 'professional', similar to the Professional Farmer (who was in his 60s). As a consequence, their external orientation (i.e., when a farmer was similar to the Aspirant Top Farmer) reduces and they naturally focus more on on-farm management, including higher on-farm diversification. Building on their past experiences, these farmers become more balanced risk-takers, taking some risks, but moderate ones.

In contrast with goals, which vary in response to several stimuli, values are more stable and, therefore, less subject to circumstantial variation (Gasson, 1973). This explained why the Committed Environmentalist, who similar to the Professional Farmer was also in his 60s, pursued a different path from the production-oriented farmers (i.e., productivist value). This means, irrespective of these farmers' age, his environmental values have played a role ever since he started farming. As farmer 02 elucidates, *"(...) [his] grandad already had this concept of taking good care of animals"*, and so did he. However, holding strong environmental values does not exclude the Committed Environmentalist from having various goals throughout his farming life, and consequently, going through similar stages to that of production-oriented farmers. For instance, this farmer's risk behaviour was likely to have varied in a similar way of the other types of farmers: when he was young, he was likely to have been more adventurous with his experiments on beef production and environmental conservation whereas with age he probably became more cautious given increased family needs. Since there were no groups of younger environmentalists farmers to confirm these hypotheses, they remain as possibilities.

6.5 Summary and Conclusions

Chapter 6 contained a description and analysis of the Brazilian innovative beef farmers' goals and values. The overall objective was to address research question one, which was concerned with whether there is diversity of goals and values among these farmers, and if, so, how this diversity is characterised. To answer this question Q-methodology was used. Innovative beef farmers were presented with 49 statements relative to family, farm and environmental goals and values, which were sorted according to these farmers' views, perceptions and beliefs. Follow-up interviews were undertaken to allow farmers to 'speak for themselves' and provided further accounts of their main goals. Four factors were identified as representative of these farmers' main views and goals, and were labelled: the Professional Farmer, the Committed Environmentalist, the Profit Maximiser and the Aspirant Top Farmer. Factor interpretation was initially undertaken within an abductive logic and was complemented by some descriptive statistics. Interpretation of the factors was further enhanced by transcripts analysis, characterising a triangulation of methods.

The results showed that, despite having a common goal of running the farm as a business, these innovative beef farmers had diverse goals and values. This diversity of goals was evident through farmers' prioritisation of statements, which collectively provided a logical structure for factor interpretation. The Professional Farmer prioritised running the farm in a professional way based on sound technical and managerial practices. The Committed Environmentalist put emphasis on sustainability and was somewhat open to sacrificing current production in order to achieve long-term results. The Profit Maximiser was someone highly focused on technically improving the farm to pursue his profit maximisation goal. Maximising profit was seen as a way of securing current and future income so that he could enjoy life. In contrast with other farmers, the Aspirant Top Farmer was tuned into a wider context of farming and focused on marketing and networking. He was seeking excellence in an attempt to be a model for his peers, from whom he accepted recognition.

These diverse goals resulted from farmers' different views on particular themes such as their attitude to risk, decision making, environmental issues, profit, business expansion and diversification, among others. Diversity in goals may also have reflected these farmers' different socio-economic conditions, particularly age and stage of life cycle at the time of the interview. There was some evidence, however, to suggest that the different farmer types operate on an evolutionary path that all farmers go through as they get older and more experienced.

The identification of farmer types, based on major goals and values, provided a better understanding of the heterogeneity within a supposedly 'homogeneous' group of innovative beef farmers, bringing to light their views. In doing so, this study of farmer types also provided some context upon which these innovative beef farmers made adoption decisions. Given these farmers' diverse goals, their approaches to farming are likely to vary accordingly, with implications for innovativeness and technology adoption.

In this chapter, some hypotheses were raised regarding the likely adoption behaviour of the four farmer types regarding production, environmental and managerial technologies. It is acknowledged, however, that without an investigation of these farmers' technological profile, no definite conclusion can be drawn. Therefore, this is the subject of Chapter 7, which focuses on how these diverse goals and values translated into the adoption of various types of technologies.

Discussions on how the findings in this chapter contribute to the body of literature on farmer types along with other theoretical considerations are provided in Chapter 9.

Chapter 7
Farmers’ Goals as Determinants of Technology Adoption

7.1 Introduction

In the last chapter, four types of innovative beef farmers were identified, embodying farmers’ diverse values and prevailing goals. Based on these values and goals, some hypotheses were formulated (Section 6.4) on these farmers’ technology adoption behaviour.

In this chapter these hypotheses are investigated and an exploration of the relationship between goals and technology adoption is presented to answer research question two (How does diversity within innovative beef farmers’ goals and values affect adoption and non-adoption of technologies?). The farmers’ actual technological profiles show their adoption and non-adoption of particular technologies, and are used to provide empirical evidence on whether these farmers’ diverse goals and values determine different adoption behaviours. Following the procedures of Grounded Theory (discussed in Chapter 5), emerging themes during the interviews explaining farmers’ adoption behaviour are incorporated to enrich the discussion.

The chapter starts with an analysis of the aggregate rates of adoption of production, environmental and managerial technologies for the farmer types (see Appendix I, for adoption rates *per* individual farmer). This analysis includes multiple loader farmers (who loaded significantly on more than one factor in the Q-sort) since the emphasis of this analysis is on the overall adoption rates of different technology types amongst innovative beef farmers. Rates of adoption reflect the percentage of eligible farmers[15] who declared they used a particular technology. Adoption was treated dichotomously (i.e., yes/no) rather than as a continuous variable (i.e., the extent of adoption) for divisible technologies. Previous interpretations of factors (Chapter 6) are often brought to discussion to explain emerging adoption patterns among the various farmer types.

Next, the adoption of 25 production technologies is analysed for the 26 innovative beef farmers as a whole, followed by the analysis of the nine environmental and the 11 managerial technologies. Emphasis is given to farmers’ accounts of their technology adoption, including some illustrative quotes. These accounts of farmers were obtained by a thorough analysis of qualitative material from the interviews, which allowed for the identification of the relevant

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[15] Eligible farmers of a particular technology were limited to cases where this technology was applicable.

factors explaining their adoption behaviour (see Appendix G, for factors mentioned by individual farmers). Through cross-case comparative analysis, emergent adoption patterns within the 26 innovative farmers were coded and are reproduced here. The outcomes of this analysis help to justify why farmers adopted some technologies but not others. A broader discussion is then undertaken to provide further insights on the determinants of these farmers' adoption behaviour. Finally, a synthesis of the main findings is presented and some conclusions are drawn.

7.2 Technological Profile of Various Types of Innovative Beef Farmers

On average, the 26 innovative beef farmers adopted 27 (60%) of the 45 technologies analysed (see Appendix C for a description of these technologies and Appendix I for the adoption rates of each technology by individual farmers). Of the three technology types, the most frequently adopted were production and managerial technologies (62% and 60% respectively) whereas environmental technologies were the least adopted (53%), as shown in Table 7.1. The adoption rates of the hypothetical farmers, represented by the four farm types plus multiple loaders, are also presented in Table 7.1. Analyses of the results follow, emphasising the influence of these farmer types, and goals thereof, on the adoption of the three technology categories. In these analyses each farmer type is treated as a single hypothetical farmer, representative of the main views of the farmers loading on it.

Table 7.1 Technology adoption rates (percent) relative to innovative beef farmer typology

Type of technology	Types of innovative beef farmers*					
	PF (n=9)	CE (n=2)	PM (n=4)	ATF (n=5)	ML (n=6)	Total (n=26)
Production (n=25)	67	46	60	60	64	62
Environmental (n=9)	55	63	36	52	58	53
Managerial (n=11)	64	55	50	65	59	60
Overall adoption rates	63	48	53	58	62	60

* PF = Professional Farmer; CE = Committed Environmentalist; PM = Profit Maximiser; ATF = Aspirant Top Farmer; ML = Multiple Loader

From a statistical standpoint, the probability of the differences in adoption rates, both within a farmer group or among the farmer types, were variable and did not all meet the standard significance levels with some differences being highly significant, but others far from conventional significance (see Appendix J). This result is mainly due to the small number of farmers involved in this analysis and the fact that, in general, adoption rates were high across farmers and technology categories (i.e. preference for particular types of technologies was less apparent). Also, the differences in adoption rates of the technology categories were susceptible to the choice of the specific 45 technologies analysed.

Nevertheless, this does not render the analysis of adoption patterns unimportant given that for these 26 innovative beef farmers the differences were real assuming they were not solely due to measurement errors. Whether these differences could be generalised to theory in terms of the influence of the farmers' goals on adoption of particular technologies categories is questionable. Reasons justifying such a generalisation include: (1) adoption rates tended to be consistent with the expected behaviour of farmers as *per* the hypotheses raised in the previous chapter; (2) the decision models, presented in Chapter 8, provide empirical data on how the farmers' goals and values influence their final adoption decision; and (3) the farmers' comments (Appendix G) back up the results in Table 7.1. Therefore, the findings taken altogether support the claim that the differences in adoption of the technology categories are somewhat likely to be relevant for the farmer types. The following analysis aims at clarifying the emerging adoption patterns.

While adoption rates of the Committed Environmentalist (CE) and the Profit Maximiser (PM) were around 50%, the rates of the Professional Farmer (PF), the Aspirant Top Farmer (ATF) and the Multiple Loaders (ML) were around 60%. This difference can be explained by the self-imposed restrictions of CE and PM farmers in relation to technologies in general. For the CE, important boundaries for technology adoption were its impact on the environment and its contribution to the overall sustainability of the farming system. Moreover, he was not interested in adopting as much technology as possible (Chapter 6), which helps to explain his 'low' adoption rates. In the case of the PM, his risk aversion along with his aim of reducing the workload was a major limit for the adoption of new technologies. In contrast, PF and ATF were more open to a wide variety of technologies, which facilitated adoption. Arguably, this explanation may be extended to ML (adoption rate of 62%) since half of its six farmers significantly loaded on factors 1 (PF) and 4 (ATF) simultaneously, and the other half loaded on at least one of these factors (Appendix G, Section G.2).

Differences were also noticed for the adoption rates of the three technology categories among the four farmer types, as hypothesised in Chapter 6. In relation to production technologies, the adoption rates of the PF, the PM and the ATF, who were production-oriented, were higher than the CE's rates of adoption, as expected. The major goals of PF, PM and ATF were to run the farm as a business, to achieve the maximum profit feasible and to maximize beef production respectively, all of which were supportive of the adoption of production technologies. In contrast, the ‘low’ adoption level (46%) of this type of technology by the Committed Environmentalist was due to a lack of priority in beef production and a major focus on conservation, as discussed in the previous chapter.

Not surprisingly, the CE type had the highest adoption rate (63%) for environmental technologies, which is consistent with his strong focus on sustainable farming. Amongst the production-oriented farmers, adoption levels varied, with the PM type achieving the lowest level of all farmer types (36%). Given this farmer’s major focus on profit maximisation, environmental technologies were generally perceived as incompatible with production, and therefore, with profits. This result reinforced the foregoing interpretation (Chapter 6) that nature conservation was not as important to this farmer type as it was for other farmers (statement 41, Table 6.7). Farmers of the PF and the ATF types had intermediate adoption rates (55% and 52% respectively). These farmer types tried to manage the farm business properly and this required attention to environmental issues, as they argued (Chapter 6).

Attempting to manage the farm properly was also a reason for farmers in the PF and in the ATF types to pay close attention to the farm management, which resulted in their high adoption rates of the 11 managerial technologies sampled (64% and 65% for these farmer types respectively). Managerial technologies were not emphasised by the CE to the same extent they were by the previous farmer types and, as a result, he had lower adoption levels (55%) compared to them. Rather than an interest in beef farming *per se*, the CE was interested in the farm long-term sustainability with emphasis on the biological interactions among the various components of the farming system. Perhaps, his adoption level would have been higher if managerial technologies to monitor environmental aspects (as opposed to the monitoring of beef production solely) were included in the sample. In contrast with the previous farmer types, the PM perceived production technologies as more important than the managerial technologies, as shown in Chapter 6. This justified the lowest rate of adoption (50%) of managerial technologies for this farmer type.

The above results indicate that the adoption of the three categories of technologies among the four types of innovative farmers generally matched the hypotheses raised in Chapter 6 (Section 6.4). In the previous chapter, it was hypothesised that the Professional Farmer’s technological profile would be characterised by higher adoption rates of production and managerial technologies compared to environmental ones, which was confirmed (see Table 7.1). The Committed Environmentalist’s higher adoption rate of environmental technologies compared to production technologies was also verified. Despite his lower adoption of managerial technologies compared to other farmer types, the rate of adoption was higher for this technology category compared to production technologies, as hypothesised in Chapter 6. The foregoing hypothesis regarding the Profit Maximiser's adoption behaviour was equally confirmed as his preference for production technologies over managerial, and more importantly, over environmental technologies was evident. Finally, the Aspirant Top Farmer adopted, as hypothesised, several managerial technologies. Additionally, his aim of seeking excellence also led him to highly adopt production and environmental technologies. Despite having the most progressive character of all farmer types, the ATF's overall adoption rate was lower than the PF's possibly as a consequence of his young age and the stage of the farm development. His willingness to adopt was probably limited by his capacity to adopt, given his still limited total net worth, as Hurley and Hult (1998) argue.

The diverse levels of adoption of production, environmental and managerial technologies amongst the four farmer types provide some evidence of the relationship between these innovative farmers' goals and values, and their actual adoption behaviour, although this relationship may not be strong. It appears that their goals provided a context for their behaviour. Nevertheless, other factors explaining these farmers' adoption and non-adoption of specific technologies were made explicit during the interviews (see Appendix G for relevant factors to individual farmers). These factors are identified, compiled and discussed in the next section for the 26 innovative farmers as a whole. The adoption rates of specific technologies by the farmer types had too many elements with small numbers for the analysis to be meaningful and were disregarded (see details in Appendix I).

7.2.1 Production technologies

On average, 62% of the 25 production technologies were adopted by the 26 Brazilian innovative beef farmers. The adoption rates of the specific production technologies related to pasture, cattle nutrition, animal health, reproduction and meat quality. They are shown in Table 7.2 and analysed subsequently.

Table 7.2 Percentage of farmers adopting particular production technologies

Production technologies	Overall adoption rate[1]	Production technologies	Overall adoption rate[1]
Pasture		***Animal health***	
Grass and legumes mix	31	Strategic control of worms	62
Deferred grazing	36	Care of newborn calves	100
Pasture diversification	42	***Reproduction***	
Pasture maintenance	48	Early weaning	5
Pasture recovery	55	Embryo transfer	11
Rotational grazing	76	Artificial insemination	63
Soil testing	81	Cross-breeding	67
Certified pasture seed	88	Genetic improved bulls	78
Cattle nutrition		Cows pregnancy test	89
Silage	42	Bull fertility test	89
Creep feeding	47	Culling based on reproduction	89
Feedlot to finishing cattle	54	Breeding season	95
Capineira	58	***Meat quality***	
Cattle supplementation	81	Castration	84

[1] Percentage based on the 26 innovative farmers less non-eligible farmers (i.e., technology is not applicable)

In general, production technologies related to animal health, reproduction and meat quality usually had higher adoption rates than those related to nutrition and pasture. However, the adoption of specific technologies within each subtype varied considerably. Several factors mentioned by farmers during their interviews explain these situations.

Analyses of the farmers' comments suggest that the negative factors resulting in low adoption of some production technologies included complexity and lack of compatibility. Perceived lack of compatibility was the key reason for the low adoption rate of early weaning, while complexity plus non-compatibility were relevant for embryo transfer. Most farmers argued that, by using early weaning, they would be preventing calves from gaining weight, which was incompatible with their objective of finishing cattle early. Likewise, embryo transfer, a demanding technology, was incompatible with farmers living in town as they would not be able to monitor this technology, unless there was a trusted person to do so. Moreover, embryo transfer was perceived as a difficult technology to implement as farmer 19 commented: *"I tried it [embryo transfer] but it was hard to reach high conception rates and I gave up"*. Among users, there were two main motivations for adoption: to rapidly improve the genetic merit of the herd and to explore niche markets to obtain high economic returns, as farmer 24 illustrates (Appendix G).

Some pasture technologies were also complex to farmers and had moderate adoption rates, despite being highly compatible with their grazing systems. The complexity involved in ‘grass and legumes mix’, for instance, may have limited its wider adoption. Farmer 25 provided an explanation, and other farmers agreed, that *“it is hard to keep the legume and after a few years it’s all gone”*. Another example was provided by farmer 3, who discontinued pasture recovery using crops after few unsuccessful attempts.

Similarly, cattle nutrition technologies also had moderate levels of adoption due to various reasons. Some farmers, like farmer 2, had a preference for natural beef systems and found nutrition technologies incompatible with their philosophy. He commented he *“did not want to feed cows as hogs”*. Other farmers (e.g., F26) believed the returns on nutrition-related technologies were unfavourable or unclear given feedstuff prices and potential weight gains, despite recognizing they were compatible with their farming systems. In contrast, users of these technologies did so because they believed in their high returns (e.g., F17), wanted to increase cattle turnover (e.g., F12), produced cash crops (e.g., F18) and/or had the facilities (e.g., manufacturing plant, staff and machinery) to prepare and distribute feed (e.g., F6).

Other relevant factors, or decision criteria, determining the adoption of production technologies included returns on investments, the technology purchase price or implementation cost, its impact on cattle turnover or on beef production, the associated risk, the workload and the requirement for specialised workforce.

7.2.2 Environmental technologies

From the nine environmental technologies, 53% were, on average, adopted by these innovative beef farmers (Table 7.1). The adoption rates of the specific technologies are presented in Table 7.3.

In general, the adoption rate of some environmental technologies was influenced by whether these technologies were seen as compatible with production goals, according to most farmers. For example, setting aside a permanent private reserve was considered incompatible with production goals, whereas manure management (for soil fertilization), agricultural terracing and other soil conservation practices (e.g., no-tillage farming) were generally seen as compatible. This partly justified the lower adoption rate of the former relative to the latter three technologies.

Table 7.3 Percentage of farmers adopting particular environmental technologies

Environmental technologies	Overall adoption rate[1]
Private reserve of the natural patrimony	8
Heavy use area protection	12
Expansion of headspring protection area	25
Manure management	38
Soil conservation practices	54
Agricultural terracing	65
Tree conservation/planting	69
Water management and facilities	92
Fire *not* used for pasture management	100

[1] Percentage based on the 26 innovative farmers less non-eligible farmers (i.e., technology is not applicable)

The environmental technologies with the highest adoption rates were 'water management and facilities' and 'fire *not* used for pasture management'. Both had high compatibility with farmers' goals and overall farm systems. One can argue that non-adoption of fire to control pasture was due to the fact it is forbidden by law. Although this certainly played a role in this decision, it is not uncommon to find farmers still using fire, as shown by Mistry (1998). So it is arguable these innovative farmers had other more advantageous practices to manage pasture than fire.

The low adoption of 'expanding the headspring protection area' and 'protecting heavy-use area' (e.g., around feeders) was generally influenced by their uncertain impact on production. For farmer 2, who was environmentally-oriented, the non-adoption of protection of heavy-use area, however, was due to its incompatibility with other practices as he clarified: *"I don't need this [to protect heavy-use area] because I move feeders around constantly so manure spreads on the paddocks and there is no soil compaction"*.

Difficulties to implement and manage some environmental technologies as well as the cost involved often led farmers to discontinue adoption. Farmer 12, for instance, started planting trees to reforest areas along the river on his property. However, he claimed it was costly and he could not avoid seedlings being destroyed by ants. For these reasons, he stopped adoption.

7.2.3 Managerial technologies

The 26 Brazilian beef farmers adopted, on average, 60% of the 11 managerial technologies investigated in this study. The adoption rates of the specific technologies are presented in Table 7.4 and the results are discussed subsequently.

Table 7.4 Percentage of farmers adopting particular managerial technologies

Managerial technologies	Overall adoption rate[1]
Analysis of total production costs	15
Operate in futures trading	17
Formal investment planning	23
Financial control	38
Staff evaluation/reward for performance	46
Participant in market alliance	77
Sanitary control (animal health calendar)	81
Managerial software	81
Animal identification	88
Scale to weigh cattle	92
Technical records (control)	100

[1] Percentage based on the 26 innovative farmers less non-eligible farmers (i.e., technology is not applicable)

Managerial technologies highly adopted by most farmers were by and large related to farm performance and production goals, and were relatively simple to adopt. In contrast, there was a range of managerial technologies, such as analysis of production costs, futures trading and use of formal planning techniques, which had low adoption rates because farmers lacked a full understanding of these technologies and believed *"this is for economists"* (F25).

Furthermore, the overall low quality of the workforce was a serious limitation for the adoption of more sophisticated technologies, such as financial control and analysis of production costs. Some routines associated with these managerial technologies require systematic data gathering and analysis, which was difficult to implement on many farms. Farmer 18, for instance, discontinued the detailed control system he had in place because of staff limitation. Farmer 9, illustrating the difficulties of running a proper cost control system, commented the main challenge he had was to require staff to get receipts for any item purchased, irrespective of the amount spent. This was a major cultural barrier both for his employees and for the local shop owners, who often did not provide them with receipts.

7.3 Discussion and Further Insights on Innovative Farmers' Technological Profile

The 26 innovative beef farmers adopted, on average, 60% of the 45 technologies analysed, with high adoption levels also observed across production, environmental and managerial technologies. This is not surprising given these farmers selected themselves into voluntary programmes or associations that require good farming practices. For instance, compared to average farmers, these innovative farmers' rates of adoption were substantially higher. The 2006 Brazilian agricultural census (IBGE, 2006) presented adoption rates of several technologies among farmers in *Mato Grosso do Sul* State, Brazil, including 29% for cattle supplementation (versus 81% in this study); 6% for artificial insemination (vs. 63% here); 1% for embryo transfer (vs. 11% among innovative farmers) and 5% for agricultural terracing (vs. 65% among the 26 innovative farmers). These results reinforce the innovative character of these participant farmers and provide evidence for the effectiveness of the sampling techniques used in this study to identify and select innovative farmers.

Furthermore, the above results put technology adoption in perspective as technologies that had presumably 'low' or 'moderate' levels of adoption in this study (e.g., embryo transfer) may still be considered highly adopted relative to average Brazilian beef farmers. For instance, the overall adoption rate of the environmental type of technology was considered 'low' in this study in comparison to the adoption rates of other types of technology. Nonetheless, these farmers' adoption of environmental technologies is likely to be considerably higher than the adoption amongst typical beef farms in *Mato Grosso do Sul* State.

In general, all highly adopted technologies were compatible with the farmers' goals and farming systems. This is made particularly clear in the analysis of the highly adopted environmental (**Error! Reference source not found.**Table 7.3) and managerial (Table 7.4) technologies, which are all closely related to production and thus, were seen as compatible with farmers' goals and farming systems. Additionally, most highly adopted technologies are relatively less complex to implement, and in some cases are more observable and divisible (i.e., enable trialling), than those technologies with lower adoption rates. Some examples include: soil testing, care of newborn calves, breeding season, water facilities, sanitary control and animal identification. Another illustration is the farmers' high adoption of reproduction-related technologies relative to those related to pasture, which are usually more complex. In contrast, technologies with low levels of adoption were not fully understood by farmers, or were seen as complex or non-compatible with these innovative beef farmers' goals and values. An example that embodies these three reasons for non-adoption was farmer 14's doubts about the benefits of working out total costs (a managerial technology): *"What is the point in having such detailed production costs? I may give up farming afterwards [after working out costs]"*.

Other attributes associated with a technology were also influential on these farmers' adoption behaviour, including both economic and non-economic factors. An example of an economic factor was the return on investment whereas the workload resulting from adoption illustrated non-economic factors. Other factors were contextual and affected adoption of technologies in general, irrespective of its type. For example, being financially constrained and having employees with low qualifications were important barriers for the overall adoption decision.

Results also suggest that farmers perceived the attributes of the technologies differently, as illustrated by the cattle nutrition technologies. Some farmers believed these technologies provide high returns while others found returns were low, given their high cost. Furthermore, it seems that compatibility is the primary technology attribute farmers consider before they proceed with the adoption analysis.

Further discussions on the technology attributes and their influence on technology adoption are undertaken in Chapter 9 in the light of Rogers' (2003) diffusion of innovations theory, incorporating other findings from this study.

7.4 Summary and Conclusions

In Chapter 7, the technological profiles of innovative farmers were investigated to find relationships between farmers' goals and adoption behaviour. Specifically, research question two was addressed as to how innovative farmers' diverse goals and values affect adoption and non-adoption of technologies. The technological profiles of the four farmer types were identified and comparisons were undertaken. Through these comparisons, some emergent adoption patterns became more evident, being discussed in detail. The discussion included farmers' accounts of their technology adoption behaviour, with some quotes being incorporated to illustrate the theme in debate.

These farmers' technology adoption was associated with their goals and values. At aggregate levels, farmers' overall adoption rates seemed to reflect their goals related to innovativeness, risk and farming as a business. Farmers who were more willing to take risks and had a production-orientation tended to adopt more technologies than farmers who were more risk neutral, risk averse or focused on environmental conservation. The analysis of aggregate adoption of production, environmental and managerial technologies tended to confirm that farmers' goals were playing a role in determining their uptake, or prioritization, of particular types of technologies. Farmers that focused on technical performance adopted more production technologies than farmers that focused on sustainability who adopted more environmental technologies. Those with an off-farm orientation, in turn, strived to manage the farm based on sound managerial technologies.

Nevertheless, goals and values did not explain by themselves farmers' adoption behaviour, as these farmers mentioned other criteria relevant for their adoption decisions. It seems that the farmers' goals and values provided a general framework upon which they assessed technologies' fit to their value systems. To be considered for adoption, a technology needed to be compatible with their goals, values and farming systems. Usually, technologies perceived as incompatible were not adopted by these innovative farmers.

Being a compatible technology was a necessary, but insufficient condition for adoption since some technologies that were apparently compatible with these farmers' goals were adopted by few farmers only. Additional factors playing a role in these farmers' adoption decision included the technology relative advantages, observability and trialability. Farmers considered a number of aspects that defined the relative advantages of a technology, including its complexity. There was some evidence that the level of importance of these aspects to individual farmers was influenced by the farmers' prevailing goals and values. Observability and trialability, in turn, facilitate but did not determine adoption, being of second importance.

With the aim of deepening the analysis of the factors, including farmers' goals, impacting on farmers' adoption behaviour, a case study of one production and one managerial technology is undertaken in the next chapter. This analysis will offer not only empirical evidence for what factors these might be, but also provide researchers' with a better understanding of the farmers' decision making process.

Chapter 8
Innovative Farmers' Adoption and Non-adoption Behaviour: Case Studies on Selected Technologies

8.1 Introduction

In the previous chapter, aggregate technology adoption behaviours were discussed in the light of innovative beef farmers' diverse goals and values. Findings suggested technologies needed to be compatible with farmers' goals, values and farming systems in order to be considered for adoption. Other factors seem to also play a role in these farmers' adoption decisions. In this chapter, the adoption decision is further analysed using a different perspective.

Empirical data from the semi-ethnographic interviews are presented within a decision tree framework, describing innovative farmers' paths towards adoption and non-adoption of technologies. This treelike model was drawn from Gladwin's Ethnographic Decision Tree Modelling (EDTM). Despite this author's claim that *"...there is no point to building a model unless one also tests it"* (Gladwin, 1989, p. 13), in this study the models were not tested as the prediction of farmers' adoption behaviour in general was not an objective. Rather, the models were developed aiming at theory formulation based on the descriptions of, and insights on, the decision paths of a specific group of farmers. This emphasis on theory building and modification follows naturally from the constructivist-interpretivist philosophy of this study. This approach leads to the development of a rich picture in which the inherent diversity of the participant farmers is cherished.

The models were initially developed based on the accounts provided by the 26 innovative beef farmers. Eight additional innovative beef farmers, also sampled from the Association of Producers of Young Steers, were included at a later stage to further develop the models and refine the understanding of the farmers' rationale (for procedure details, refer to Chapter 5, Section 5.4.4.2). The composite (aggregate) tree models are presented in this chapter, and included only the main decision criteria considered by farmers. The models were considered appropriate if they provided insightful information on farmers' adoption decisions. This is consistent with Soft Systems Thinking, described in Chapter 5 and used here as a framework. Under SST, the enquiry should contribute to throw light in the problem situation (i.e. farmers' decision process) in order to improve it rather than to solve it.

The adoption decisions on two technologies were modelled to address research question number three, that is: 'Do innovative beef farmers use a different set of constructs when assessing different types of technologies? If so, why?' The first tree model refers to adopting a protein-salt complex as a supplement for rearing cattle during the dry season. The second tree model represents farmers' decision on working out the cost of beef production, including depreciation and opportunity costs. The selection of these two technologies is justified in sections 8.2.1 and 8.2.2. These two technologies are contrasting in two dimensions: (1) type of technology; (2) nature of technology. Cattle supplementation is a production type of technology and has a 'hard'[16] nature whereas cost analysis is a managerial type of technology and has a 'soft' nature. To elicit innovative farmers' decision criteria and map out the decision-making process, they were asked several direct simple questions (e.g., "why do you do control costs?") and invited to explain contrasting adoption behaviours (e.g., "why do you supplement cattle during the dry season but not during the rainy season?").

The model display generally follows Gladwin's (1989) outline, with the alternative decisions at the top of the model accompanied by the number of farmers entering the decision tree. Decision criteria are presented as numbered questions in boxes, preceded by the main theme they referred to (in bold). The arrows indicate farmers' responses to these questions and the different sequences of arrows show their paths down the tree model, following the convention: 'No' answers lead farmers to the right side of the tree model; and 'Yes' answers lead them to the left. Each answer (i.e., 'Yes' and 'No') is accompanied by the number of farmers taking that path (the additional farmers' paths are in parentheses). For clarity, case numbers are shown in brackets for each outcome so that farmers' paths are visible. Main 'unless conditions' are added to the models to allow farmers to discontinue former choices should they came across constraints to adoption. Other 'unless conditions' that followed no particular logical ordering, but were still important to farmers, are reported separately.

Results are discussed for each decision model individually and later used in comparisons between models. This comparative analysis provides the basis for subsequent discussions on innovative farmers' adoption and non-adoption behaviours.

8.2 Adoption and Non-adoption of a Production and a Managerial Technology: a Case Study

In Chapter 7, a wide list of 45 technologies, involving production, environmental and managerial innovations was presented, and farmers' aggregate adoption and non-adoption

[16] In brief, 'hard' technology is tangible whereas 'soft' technology is intangible (Jin, 2002). For a detailed definition of 'hard' and 'soft' technology, see Chapter 1.

behaviours were discussed. As noted, in this section, a case study of one production and one managerial technology is undertaken. Specifically, this analysis is aimed at describing farmers' technology adoption and non-adoption, identifying relevant contributing factors for adoption behaviour and associated decision paths for both technologies. Comparisons between these paths are made to identify similarities and differences on how farmers construed a 'hard' production and a 'soft' managerial technology as well as to provide the reasons for these constructions.

The 26 innovative beef farmers' adoption of cattle supplementation and cost analysis is presented in Table 8.1. The table is organised to facilitate the analysis of emerging patterns. Thus, farmers are initially divided in two groups (marked by the dashed line): non-adopters and adopters of cattle supplementation. Within each group, farmers are ordered according to the factor they loaded on to in the Q-sort analysis (Chapter 6), and then, by case number.

Table 8.1 Innovative beef farmers' adoption and non-adoption of cattle supplementation and cost analysis

Case	***Production***[2]	***Managerial***[2]			
number[1]	**Supplementation**	**Total cost**	**Operational cost**	**Cash cost**	**No cost**
08 (1)	-				✓
11 (1)	-			✓	
26 (1)	**N.A.**	✓			
02 (2)	-			✓	
16 (2)	-				✓
03 (4)	**N.A.**		✓		
04 (4)	-			✓	
19 (m)	-		✓		
20 (m)	-				✓
25 (m)	-			✓	
05 (1)	✓			✓	
07 (1)	✓			✓	
10 (1)	✓			✓	
13 (1)	✓				✓
17 (1)	✓			✓	
18 (1)	✓		✓		
12 (3)	✓				✓
14 (3)	✓				✓
15 (3)	✓			✓	
22 (3)	✓				✓
01 (4)	✓			✓	
06 (4)	✓	✓			
09 (4)	✓	✓			
21 (m)	✓			✓	
23 (m)	✓	✓			
24 (m)	✓			✓	

[1] Numbers in brackets refer to factors that farmers loaded on to in the Q-sort (i.e., farmer types from Chapter 6); 'm' stands for multiple loader.
[2] (-) indicates non-adoption; ✓ indicates adoption; and N.A. stands for non-applicable.

In general, there was no clear correlation between the adoption of cattle supplementation and cost analysis. However, when adoption of both technologies were analysed considering the farmer types (factors one to four) and multiple loaders, a more convincing pattern seemed to emerge. Farmers in factor one (i.e., the Professional Farmer) tended to supplement cattle and undertook at least a basic, if not a more complete, cost analysis. This was in accordance with their goals of running the farm professionally and trying to tackle production and managerial issues equally. Farmers in factor two (i.e., the Committed Environmentalist), who strived to pursue an environmentally friendly production system, did not supplement cattle. They also tended towards a simple cost analysis, if any, for reasons unknown at this stage. All farmers in factor three (i.e., the Profit Maximiser) supplemented their cattle, with most of them not analysing beef costs (i.e., intuitive farmers), except farmer 15 who had a basic cost control. This adoption behaviour supported previous interpretations of farmers in this factor as focused on technical rather than managerial issues. While economists would strongly disagree with the idea that a farmer could try to maximise profit with no cost accounting, this seemed to be disregarded by this farmer type. Given supplementation was not applicable to farmer 03's case, it can be argued that almost all farmers in factor four (i.e., the Aspirant Top Farmer) also supplemented rearing cattle during the dry season. Additionally, their willingness for sound managerial practices was further reinforced by the fact most factor four farmers undertook sophisticated cost analysis, working out either operational or total costs. In contrast with previous farmer types, there were no major adoption patterns emerging from multiple loader farmers whose 'group' behaviour seemed somewhat random.

The above results suggest that farmers' adoption behaviours seemed to be influenced by their prevailing goals. Results also showed that decisions on cattle supplementation and cost analysis were made independently, so the adoption of the production technology was not associated with the adoption of the managerial technology and vice-versa.

Besides farmers' overall goals, it is possible that individual farmers had other motivations to justify their adoption and non-adoption of the two technologies (Table 8.1), as discussed in Chapter 7. With the purpose of investigating why individual farmers did or did not adopt cattle supplementation and cost analysis, the following sub-sections describe and discuss their decision making processes.

8.2.1 Technical decision: 'supplement rearing cattle with protein-salt complex during the dry season?'

Supplementation can be used for any cattle category (e.g., age, gender, purpose) and in any season (i.e., dry and rainy seasons) but for different purposes. Accordingly, a clear specification of the model is necessary to avoid the inclusion of criteria that belong to other decision trees (i.e., supplementation of another cattle category, or in another season). In this study, only the decision to supplement rearing cattle with the protein-salt complex during the dry season was modelled given its high impact on beef farming. Empirical adoption data refer to the dry season of 2008 (April to October) with the interviews occurring from November/2008 to January/2009. In total, 21 out of 34 innovative beef farmers supplemented rearing cattle and the accounts of their decision making processes are represented in the following decision tree model (Figures 8.1 and 8.2). The paths of the eight additional farmers (cases 27 to 34) are reported in parentheses after 'yes' and 'no' responses in the model.

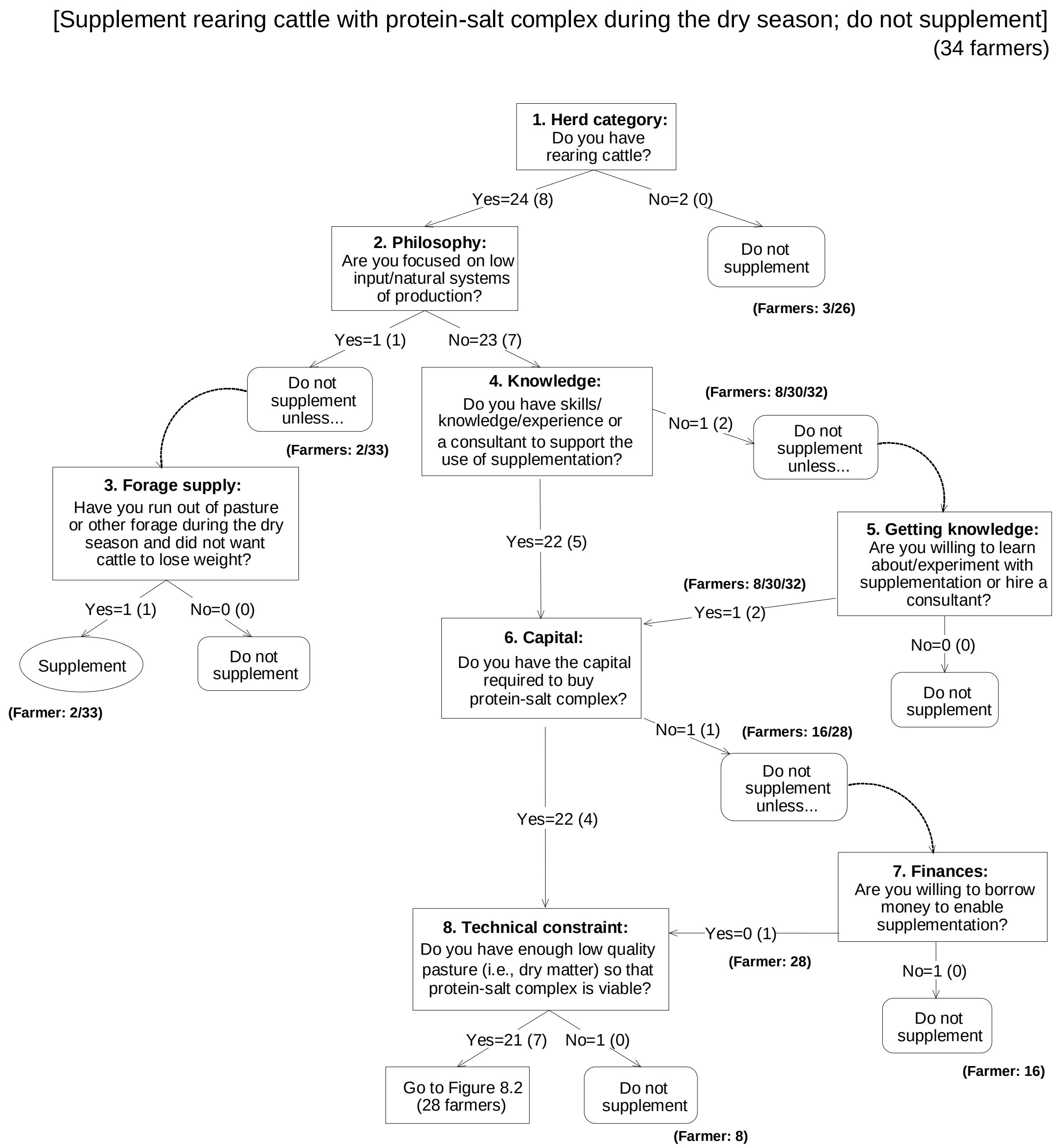


Figure 8.1 Elimination criteria for the supplementation decision

In general, all 34 farmers had grazing systems with some farmers finishing cattle under feedlot. They commonly perceived grass-fed cattle as the cheapest and more preferable way of producing beef. However, they also acknowledged they face serious pasture constraints during the dry season and tried to overcome such a constraint, undertaking various strategies: cattle supplementation was one of them.

Decisions on rearing cattle supplementation were made in two stages: the first stage involved elimination criteria 1 to 8 (Figure 8.1) and the second stage comprised motivational criteria 9 to 18 (Figure 8.2). In the first stage of the decision-making process, farmers did not consider supplementation if it was incompatible with their current system of production (criteria 1 and 2) or eliminated it if they were constrained by any criteria between 4 and 8. Incompatibility led farmers 03 and 26, who did not farm rearing cattle (criterion 1), to disregard supplementation. Farmers 02 and 33 also eliminated supplementation because they had a philosophy of running a natural beef system (criterion 2). Farmer 02 was *"satisfied"* with current levels of production, workload and income and had no motivation to change these, despite acknowledging supplementation would increase his production and profit. Farmer 33, who also agreed with criterion 2, wanted to reduce chemicals on his farm and run the farm naturally. However, if there was pasture shortage, perhaps because the beef system was not stable, both farmers would supplement cattle to prevent starvation. This possibility was represented by an 'unless condition' (criterion 3) in the model. As farmer 33 justified, *"there is still no way to go around the dry season without supplementation"*. Surprisingly, farmer 16, who belonged to the Committed Environmentalist type, did not agree with criterion 2 and 'went down' the central part of the decision model.

Farmers' lack of knowledge on supplementation, represented by criteria 4 and 5, was an important constraint to adoption given the complex interaction between cattle biological processes and diet content. Criterion 4 included not only farmers' skills and formal (e.g., agriculture-related degree) and informal knowledge, but also the option of having a consultant. Farmers constrained by this criterion, such as farmers 08, 30 and 32, went to the right path into criterion 5. This was an 'unless condition' that referred to farmers' willingness to overcome the previous constraint by either learning about supplementation (including its costs and risks) or hiring a professional to support cattle nutrition. Farmers 08 and 32 passed this criterion because they were learning about supplementation and farmer 30 because he had a consultant to implement the supplementation strategy. Therefore, these three farmers went back to the main path, joining the other 27 farmers.

A lack of capital (criterion 6) was important for farmers 16 and 28. Farmer 16, who was financially constrained, did not have enough cash to invest in the farm and was not willing to externally finance farming operations (criterion7), so beef production has fallen. As production decreased, so did margins and his ability to reinvest in the farm. This constraint precluded using rearing cattle supplementation and caused him to prioritise supplementation to finishing cattle whose returns were perceived as faster and safer. Farmer 28 also had financial constraints (criterion 6), but was borrowing money (criterion 7) to overcome this constraint and consequently, went back to the main decision path.

Criterion 8 introduced a technical constraint in the model: lack of pasture dry matter. The shortage of pasture supply makes protein-salt complex nonviable since its purpose is to maximise pasture digestibility and allow cattle to maintain or slightly gain weight. Therefore, the lack of dry matter prevented farmers, like farmer 08, from supplementation with the protein-salt complex. This farmer's lack of experience in beef farming and, in particular, in supplementation led him to a situation of overgrazed pasture in which the use of protein-salt complex was not justified. Since he was learning about supplementation, he was hopeful to start supplementing some mobs in the following year.

The 28 remaining farmers who passed all the constraints of the first stage 'went down' the second stage of the decision-making process (Figure 8.2). For each outcome (end of path), farmers' case numbers are presented, although along the path these numbers are omitted to avoid unnecessary complication. In addition, a detailed description of individual farmers' paths follows each model.

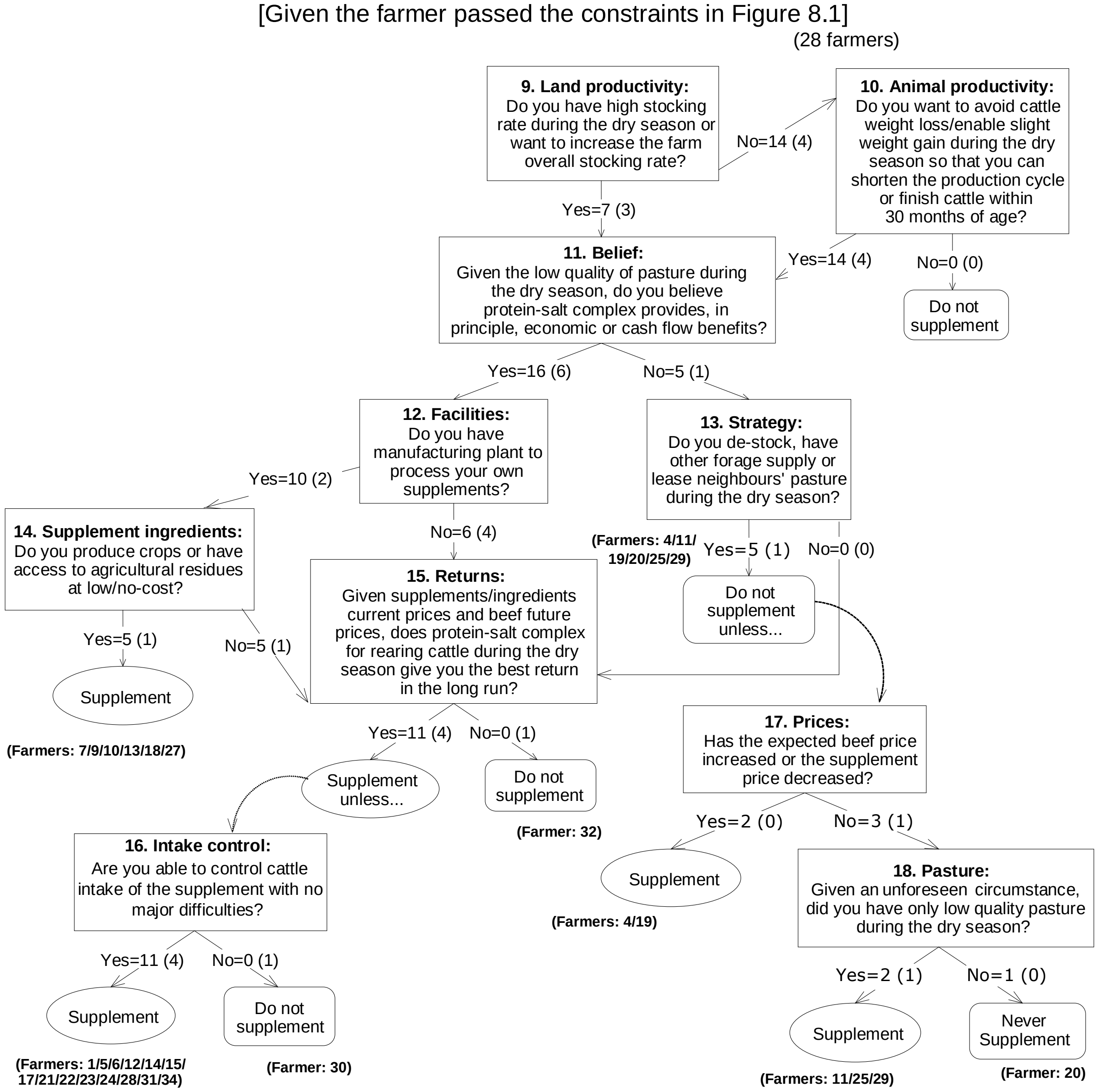


Figure 8.2 Motivations for supplementing rearing cattle with protein-salt complex during the dry season

The second stage of the decision-making process started with farmers' overall objectives, which provided some context for their decision paths. These objectives were related to stocking rates (i.e., land productivity) or cattle turnover (i.e., animal productivity), represented by criteria 9 and 10 respectively. From the 28 farmers entering the second stage of decision making, criterion 9 was relevant to ten farmers (1, 6, 9, 10, 15, 18, 21, 27, 32 and 34) because some of them had intensive systems of production and wanted to maintain high stocking rates, including during the dry season; for others, it was important because they wanted to intensify the production system and increase the overall stocking rate (i.e., increase the herd). The 18 remaining farmers were more focused on improving animal performance so that they could finish cattle within 30 months or shorten the cycle of production. As these 18 farmers agreed with criterion 10, they took a loop back to the main path and joined the previous group. As the model suggests, any of these objectives (criteria 9 or 10) led farmers towards supplementation (left hand side). In contrast, those who had none of these objectives did not supplement rearing cattle during the dry season. In this study, though, this remained as a theoretical alternative as there were no farmers taking this path.

Farmers' objectives (criteria 9 and 10) were followed by criterion 11 which reflected farmers' preconceived idea about the protein-salt complex. This was a major driver for decision-making because it caused the decision tree to split into two major branches: (1) on the right, six farmers who, in principle, had a negative perception of supplementation and generally believed it was expensive, found returns on rearing cattle supplementation often unclear or believed other alternatives were economically more viable; (2) on the left, 22 farmers who believed supplementation was economically viable, and thus, had a positive assessment of this technology.

The six farmers (4, 11, 19, 20, 25 and 29) who perceived rearing cattle supplementation as not economically attractive had alternative strategies to overcome the lack of pasture quality during the dry season (criterion 13). Such strategies in general involved decreasing the grazing pressure and included: de-stocking, alternative forage supply (e.g., sugarcane and millet), neighbours' pasture lease (i.e., run-off system) or use of a feedlot for finishing cattle during the dry season to make room for other grazing animals. In some cases, deferred grazing was used, where some paddocks were reserved during the rainy season for later consumption during the dry season.

Criteria 17 and 18 were 'unless conditions' that were identified as relevant to some of these six farmers and would make them consider adoption of cattle supplementation. Farmers 4 and 19 were price-sensitive and would consider supplementation if supplement prices drop or beef prices increase (criterion 17). Arguably, price changes have an impact on these farmers' perceptions of, and possibly beliefs on, supplementation viability. Farmers 11, 25 and 29, in turn, would start rearing cattle supplementation if for any unforeseen circumstance there was only low quality pasture during the dry season (criterion 18). In this specific situation, supplementation could provide some immediate economic benefits (e.g., maintenance of cattle weight and reduction of grazing pressure) as well as future cash flow benefits. Provided there was no alternative forage, the risk of not supplementing cattle outweighed the cost of supplementation and they would shift their decision towards supplementation. In contrast with the previous five farmers, farmer 20 would not supplement his rearing cattle (as well as his finishing cattle) in any circumstances, as he was convinced this was not profitable. Instead, he put in place deferred grazing during the rainy season in order to have pasture during the dry season when he also provided cattle with sugarcane. The only animal category that farmer 20 supplemented was suckling calves through a creep-feeding system. Although he acknowledged its high cost, he believed the returns were even greater as breeding cows recover more rapidly, calves are heavier at weaning and their stress levels post-weaning decrease.

The 22 farmers who perceived rearing cattle supplementation as an economically viable alternative 'went down' the left path at criterion 11 of the decision tree model (Figure 8.2). Twelve farmers had a manufacturing plant while ten did not (criterion 12). Having a plant was an enabling factor for supplementation that consistently emerged from adopters' data, although not consciously brought into their explanation of their decision. Half of the farmers who had a manufacturing plants (i.e., farmers 7, 9, 10, 13, 18 and 27) also produced crops or had access to low/no-cost agricultural residues (criterion 14). Residues were bought at low cost if farmers were members of agricultural cooperatives or were close to factories that supplied by-products (e.g., sugarcane bagasse); no-cost residues were obtained through the pre-processing of their own cash crop production. Irrespective of the case, the decision was straightforward and all these six farmers supplemented rearing cattle. The other half of the farmers (1, 6, 12, 14, 17 and 31), who also had a manufacturing plant (criterion 12), but did not produce crops (criterion 14), had to buy supplement ingredients to produce the supplement themselves. In this case, they went to criterion (15) and analysed supplementation returns, given the prices of supplement ingredients.

Likewise, the ten farmers (5, 15, 21, 22, 23, 24, 27, 28, 30, 31, 32 and 34), who did not have a manufacturing plant (criterion 12), had to consider buying feedstuff; in this case, the protein-salt complex rather than the supplement ingredients. Therefore, they also went to criterion 15. From 16 farmers who reached criterion 15, 15 agreed the protein-salt complex had the best return given ingredients or supplement prices at the time of the decision and predicted sale beef prices. The exception was farmer 32 who decided not to supplement cattle in the last dry season despite generally assessing cattle supplementation positively (criterion 11). He argued the drought was not too severe and he had some pasture available, which in his view, was the best return strategy under this circumstance. His decision provided some empirical evidence for this path, which at the time of the initial model building was a theoretical outcome, as none of the 26 original farmers took this path. This enhanced the model, therefore.

The 15 farmers who agreed with criterion 15 all decided to supplement cattle unless one constraint occurred: they found it hard to control cattle intake of protein-salt complex or had other difficulties in handling supplementation (criterion 16). Although the difficulties associated with protein-salt complex use was mentioned by some of the 26 original innovative farmers, it seemed not to be a decisive criterion until farmer 30 (from the additional sample) mentioned this as the main reason for his non-adoption behaviour. His contribution enhanced the original model by the addition of this ‘unless condition’ (criterion 16). The model, therefore, indicates that while many farmers acknowledged there were some challenges involved in dry season supplementation with the protein-salt complex, for some farmers this did not preclude supplementation whereas for others this was a serious limitation.

The decision tree model on cattle supplementation illustrated farmers’ *main* rationale for adoption and non-adoption of this technology based on decision criteria that farmers used. Given the model was a simplification of farmers’ rationale to help the researcher to make sense of their decision making processes (as *per* Soft Systems Thinking), other factors were identified that would change their assessment of the decision criteria in the tree. These factors were not included in the decision model because they would make it overly complex and they did not follow a specific ordering. For clarity, these factors are reported in Tables 8.2 and 8.3 for adopters and non-adopters respectively of the protein salt complex for rearing cattle during the dry season.

Table 8.2 Decision factors leading 21 adopters to discontinue supplementation during the dry season (number and percentage of farmers)

Type of factor	Decision factors	No.	%
Technical	A. Good pasture is available	15	71
	B. Other forage is available	4	19
	C. Shortage of dry matter (e.g., overgrazing)	1	5
	D. Problems with logistics	1	5
Financial	E. Price of supplements (or ingredients) rises	5	24
	F. Unfavourable cost-benefit	5	24
	G. Beef premium ceases	3	14
	H. Beef price drops	3	14
	I. Cash flow constraint	3	14

The reasons to discontinue adoption were related to technical and financial aspects. The main technical aspect was the availability of good quality pasture; this was mentioned by farmers 1, 5, 6, 7, 9, 10, 13, 15, 17, 18, 21, 23, 24, 27 and 31. In general, these farmers had a preference for grazing systems and would stop supplementation as soon as pasture recovered from the lack of rain and sun light from tropical winters. For farmers 1, 9 and 23, pasture availability would cause them to shift from dry to rainy season supplementation. Farmers 12 and 22 who also used rainy season supplementation, in contrast, did not mention the factor ‘good pasture available’. Probably, they were considering supplementation as a whole and not specifically during the dry season. As they supplemented cattle all year round, irrespective of the season, this criterion was possibly irrelevant to these farmers. Another reason to discontinue supplementation, mentioned by farmers 9, 10, 13 and 27, was the availability of other forage such as silage, fresh sugarcane or crop harvested areas where cattle could graze.

The other two technical criteria that were constraints to adoption and, if present led farmers to stop supplementation, were the logistics for feed distribution and the shortage of dry matter. The latter could stop farmer 14 from supplementing rearing cattle with the protein-salt complex because this supplement requires dry matter to work efficiently. Logistics were a constraint mentioned by farmer 5, whose herd was large. During the dry season, his feedlot operation and his rearing herd sometimes compete for machinery and staff. In this case, farmer 5 would allocate these limited resources according to returns and risk: usually, finishing cattle would be prioritised because they have higher associated risks should cattle are not finished properly (e.g., discounted beef price) and because finishing cattle provide him with more immediate returns than rearing cattle. Within his rearing herd, the same rationale applies: if farmer 5 was constrained by logistics, he would supplement store steers, but not yearling heifers during the dry season. This was because returns on the former are more secure than on the latter, given the uncertainties as to whether to fatten heifers for slaughter or use them as replacements in the breeding herd.

Financial factors would also lead farmers to discontinue rearing cattle supplementation during the dry season. Some of these financial conditions related to a farmers’ ability to afford supplementation and included: constraints on the cash flow (as mentioned by farmers 14, 22 and 24) or an increased price of the protein-salt complex or its ingredients (as farmers 15, 17, 23 and 31 claimed). Other financial factors affected farmers’ perceptions and included low beef prices (farmers 13, 14 and 22); end of premium price programme (farmers 6, 7 and 12); and an unfavourable cost-benefit ratio (6, 9, 12, 15 and 21).

In contrast with the group of adopters, 11 innovative farmers[17] who did not supplement cattle pointed out several factors also related to technical and financial aspects that would lead them to consider supplementation (Table 8.3).

[17] Farmers 3 and 26 were not considered in this figure because they did not have rearing cattle and, consequently, supplementation was non-applicable.

Table 8.3 Decision factors leading 11 non-adopters to start supplementation during the dry season (number and percentage of farmers)

Type of factor	Decision factors	No.	%
Technical	A. Low quality pasture is available	7	63
	B. Need to anticipate slaughter	3	27
	C. Weaners are weak or light	1	9
	D. Supplement intake is easily controlled	1	9
Financial	E. Price of supplements decreases	3	27
	F. Beef price increase	1	9
	G. Enabling cash flow	1	9

Among technical factors, lack of good quality pasture was the main concern and would make farmers 2, 8, 11, 19, 25, 29 and 32 supplement rearing cattle with the protein-salt complex during the dry season. Farmers 2 and 11 also claimed, and farmer 30 also agreed, they would start supplementation if they needed to anticipate slaughter or finish cattle by a due date. Usually, three situations pushed farmers to finish cattle faster: (1) a farmers' self imposed deadline so that they manage to finish cattle before the next dry season; (2) a predicted increase in beef prices; or (3) commitments with slaughterhouses. Having light calves, or calves that need to recover from post-weaning stress, was a reason mentioned by farmer 4. Farmer 30, from the additional sample of farmers, would consider supplementation if the problem of controlling cattle supplement intake was sorted.

Among financial factors, those with impact on farmers' perceptions on returns would trigger non-adopters to consider supplementation. These factors included the decrease in supplement prices, for farmers 4, 19 and 32, and the increase in beef prices, for farmer 19. Farmer 8 would consider this technology if he had a cash flow that enabled him to use it.

Different from the previous farmers, farmers 16 and 20 were persistent non-adopters as there was no single reason that would make them consider supplementation. Despite being constrained by the cash flow (Figure 8.1) and not being able to afford supplementation, farmer 16 did not mention 'availability of cash' as a motivation for adoption. Rather, he claimed he did not need to supplement rearing cattle as he has often met market requirements without it. However, since he acknowledged his scale of production has been decreasing, with pasture becoming more degraded, it is likely he will eventually face the decision to either supplement cattle or improve the pasture. Farmer 20, in turn, did not consider supplementation because he was convinced that a *"grazing system based on abundant forage supply all year round"* was the best strategy.

Some criteria that were not included in the decision tree model (Figures 8.1 and 8.2) belonged to other, usually related, decision-making processes. Examples were ‘beef premium price’ and ‘cattle breeds’. The impact of beef premium price was important to decisions at a higher level, i.e., in defining the whole production system (prior decision), of which supplementation was part. In order to assess beef premium prices farmers were required to produce young heifers and this justified why several of them focused on only farming heifers and had as a goal to shorten the production cycle. The decision of farmers 1, 7, 10 and 15, for instance, to rear and finish only heifers provided some empirical evidence for this case. They expected to get better returns with this system, given the lower purchase price for yearling heifers compared to steers, as well as the premium price they qualified for. For other farmers, such as 13, 22 and 24, the beef premium price did not impact on their supplementation decisions since they claimed they had been supplementing rearing cattle before the establishment of the premium price programme. For farmer 23, the premium price affected his decision to start supplementation during the rainy season given he was already supplementing rearing cattle in the dry season. Additional evidence that premium price was not decisive for rearing cattle supplementation was that only two farmers would discontinue supplementation if the programme ceased. This suggests that farmers who supplemented rearing cattle during the dry season did so irrespective of the premium price, although this might have been an important trigger for initial adoption. After experiencing other benefits of cattle supplementation during the dry season, they were committed to this technology and believed this was an *“essential practice if one wants to shorten the production cycle”*, as farmer 24 asserted.

Breed was another criterion that the model did not account for despite being mentioned by several farmers. The construct ‘early versus late breed’, however, seemed to be relevant for the decision on supplementing finishing rather than rearing cattle. Some farmers, for instance, claimed they had early (i.e., European breeds) or crossbred cattle to decrease the supplementation demand during the finishing phase. This demand was referred to as the length of supplementation rather than the decision on whether to supplement. Additionally, there was no clear pattern emerging from the supplementation adoption and cattle breeds data. Clearly, the interactions of cattle breeds with other factors, such as pasture management and cattle handling, proved to be more complex than a simple ‘if...then’ rule.

8.2.2 Managerial decision: ‘work out total production cost?’

Production cost analysis is one example of managerial technology that has been traditionally overlooked by beef farmers. For instance, only four (15%) of the 26 innovative beef farmers originally considered in this study, and none of the eight included later, worked out total production costs. The reasons for adoption and non-adoption of this technology are discussed next.

Accounts of the 34 innovative farmers on the production cost analysis were modelled as shown in Figure 8.3. The elicitation of farmers' decision criteria was based on questions regarding their farm management, in general, and beef costs, in particular, over the period between 01/07/2007 and 30/06/2008. Individual ethnographic decision tree models were built and later combined into a composite decision tree model. The process of developing a composite model for cost analysis proved challenging given its 'soft' nature. The nature of this technology allowed for various interpretations on production costs and their components. For instance, most interviewees claimed they knew their beef costs and that they included *"everything"* in their analysis. However, when probed further, it was clear each farmer had a different understanding of what *"everything"* meant. For some farmers, *"everything"* meant all cash and non-cash costs whereas for others *"everything"* comprised cash costs only.

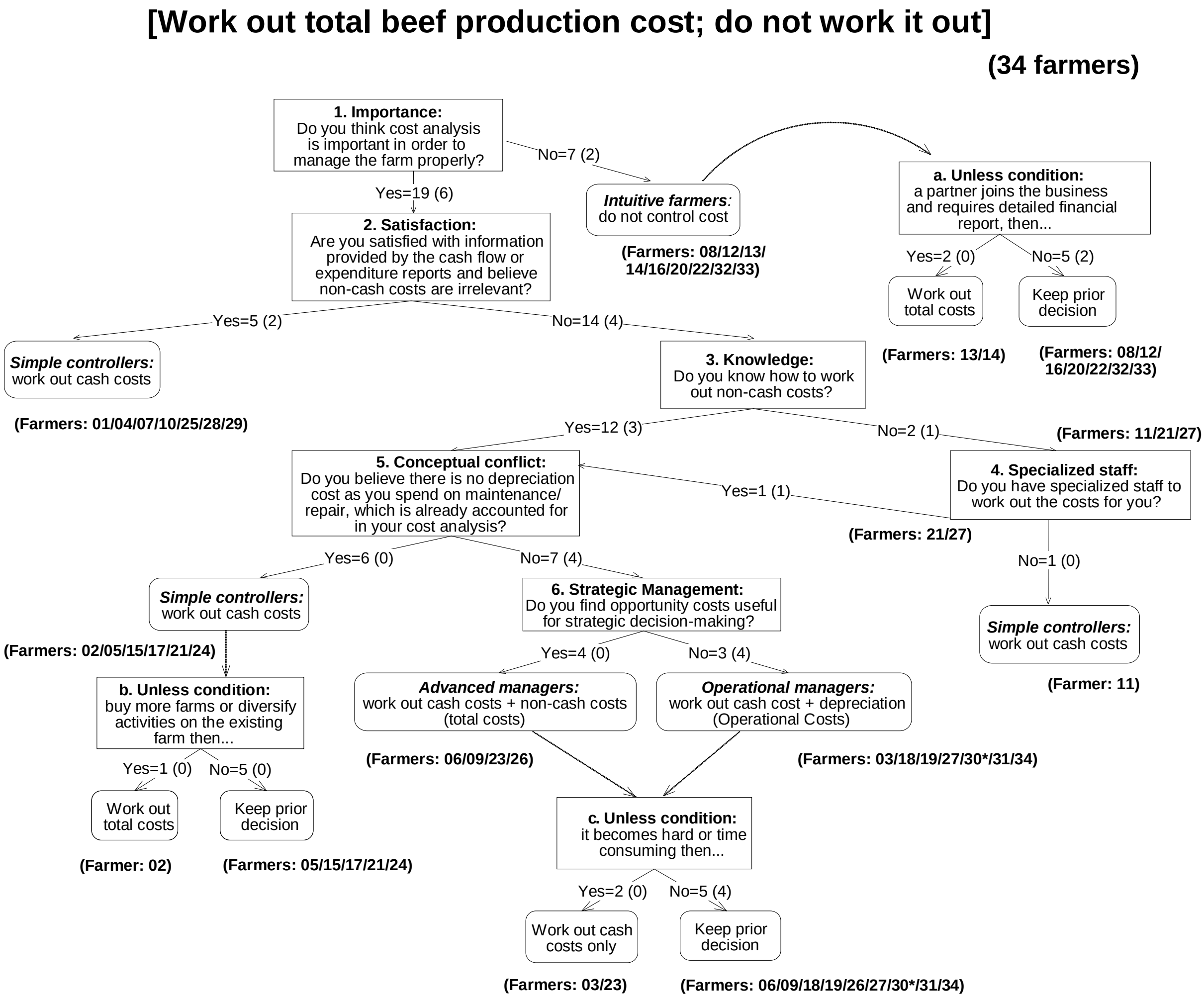
The level of sophistication of farmers' cash cost control also varied, with some farmers working out personal and farm expenditure separately; some paying themselves a wage; some with different accounts for different enterprises (e.g., cattle, crop and administration centres) whereas others worked out total expenditure, irrespective of its origin. To deal with such diversity, decision criteria were slightly changed into higher order criteria (i.e., more general criteria) in the decision tree model. These changes were limited in scope so that decision criteria remained 'emic' [18] (as opposed to 'etic' criteria) and faithful to farmers' claims.

Given farmers presented diverse levels of sophistication of their cost analysis system, adoption and non-adoption behaviours were grouped in four major outcomes: (1) no cost of production at all (non-adoption); (2) cash cost control only (partial adoption); (3) operational cost, that is cash cost plus depreciation cost (partial adoption); and (4) total cost, that is cash cost plus depreciation cost plus opportunity cost (full adoption). Although in theory farmers have the choice of working out any separate, or a combination of, cost components, these innovative farmers followed the sequence defined above.

The 34 farmers' decision paths (Figure 8.3) showed there were nine farmers who had no formal cost analysis system, 14 who controlled cash costs only, six for whom depreciation was additionally important and four farmers who worked out total production costs, including depreciation and opportunity costs. There was one farmer (farmer 30) with an idiosyncratic

[18] 'Emic' means defined by participants themselves while 'etic' means defined by outsiders (e.g., researchers). For more details, see Chapter 3 (Section 3.7).

view and for whom the model did not fully represent his decision making process, as discussed later in this section.



*The model did not represent farmer 30's actual decision path.

Figure 8.3 Ethnographic decision tree model for the adoption and non-adoption of total production cost analysis

Like the decision tree on cattle supplementation, the decision tree model on cost analysis (Figure 8.3) comprised two stages: (1) elimination-by-aspect stage (criterion 1 to 4); and (2) 'hard core' stage (criterion 5 and 6). Within the first stage, criteria 1 and 2 were pre-attentive, as farmers' decisions not to work out total production costs were made rapidly, often subconsciously. Farmers facing criteria 3 and 4 gave some consideration to working out total production costs, but decided not to do it if they were constrained by one of these two criteria and were not willing to take action to overcome it. Only farmers who passed these four initial criteria considered cost analysis in some depth. Farmers' decision paths, and decision criteria thereof, will be described in detail subsequently.

Nine farmers did not really consider working out total production costs as they believed this was irrelevant for managing the farm properly (criterion 1). These nine farmers (08, 12, 13, 14, 16, 20, 22, 32 and 33) believed the farm was *"doing fine"* as they have been *"able to pay their bills and improve the farm"*, so there was no need for cost control. In general, these farmers had a lack of interest in financial management, particularly farmers 14 and 22, who maintained the technical side of production was more important for performance than the managerial tasks. Despite not working out total costs, farmer 14 eventually worked out the margins of specific farm operations (e.g., feedlot) to assess its performance. Farmer 8 was not only uninterested in cost analysis but also found *"it was too hard to work out costs, given the dynamics of cattle production"*.

Given these farmers' lack of formal financial control, decisions on operational expenditure and investments were primarily based on their available finance, provided by bank statements. Financial reports were prepared solely for tax purpose, usually once a year. This means that all these farmers shared a management style mainly based on intuition. The fact that five of the nine farmers had completed primary or secondary education only and were among the eldest of all farmers (over 65 years old) may provide some insights as to why they managed the farm intuitively. Their level of education might have limited their understanding of some complex concepts involved in the analysis of total production costs, such as opportunity costs. Also, their non-adoption behaviour might have reflected societal views of older generations. Previous generations accepted the focus on production and productivity as 'good farming' while farm management was kept as simple as possible. This was enabled by a favourable external environment in which the lack of regulations and the low market requirements aligned to abundant subsidised credit, all justified a lack of interest in managerial issues.

Although the 25 remaining farmers acknowledged intuition was important in business, it was not enough to manage the farm properly. They believed cost analysis was also important because they wanted to know exactly where their *"money was being spent on"*; some farmers in more detail than others. Thus, criterion 1 was relevant for all these 25 farmers: they kept expenditure reports and most of them also controlled the cash flow. For this purpose, all used computers, with 21 of the 25 farmers developing spreadsheets themselves, or hiring a consultant to do so. Only four farmers (05, 10, 23 and 26) bought financial software packages.

Criterion 2 was relevant for seven (01, 04, 07, 10, 25, 28 and 29) of the 25 farmers who passed criterion 1. These seven farmers were satisfied with the information provided by their expenditure reports and found non-cash costs irrelevant to their farm management. As a result, they worked out cash costs only (i.e., transactions where there is cash transfer) and were labelled ‘simple controllers’. Their philosophy was to keep financial control simple since they knew (gross) *“margins were positive”* and, thus, believed there was no need for a *“too sophisticated”* cost analysis. The level of analysis sophistication varied among them and so did their understanding of what was considered *“sophisticated”*. Farmers 25 and 28 had the simplest cash flow control among the seven farmers: they recorded revenue and expenditure and once a month worked out the balance. Farmer 01 also kept these records but split them into two different accounts: the beef account, where variable cash costs were recorded; and the farm account, where fixed cash costs such as wages, loan repayments and land tax were recorded. Similar cost structures were used by the remaining farmers, the difference being that the accounts included other components. Farmer 04, who had an off-farm business, organised his cost control into a personal account, a farm account and a non-farm account. Farmers 07, 10 and 29 had on-farm diversification. The first two farmers organised the record-keeping system into different accounts so that they were able to discriminate major expenditure groups (e.g., personal, beef and non-beef cash costs); farmer 29 recorded all expenditure together.

In addition to total cash cost control, these seven farmers used other strategies to support their farm management. Farmers 01, 04, 10 and 29, for instance, also worked out unit cash costs. Farmers 01 and 04, who only produced beef, calculated cash costs/head whereas farmers 10 and 29 calculated cash costs/hectare allowing for land use comparisons between the beef and crop production. When making investment decisions, all of these farmers analysed potential returns on investment and the cost-benefit of technologies; farmers 25 and 29 also used partial budgeting.

In contrast with the previous group of farmers, 18 farmers disagreed with criterion 2 and ‘went down’ to criterion 3 on the right hand side of the decision tree model (Figure 8.3). In these farmers’ views, cash cost control did not provide sufficient information to support the farm management and they considered other cost components. At this stage, knowledge-related criteria (criteria 3 and 4) emerged in the model, since a good understanding of cost components is required as the cost analysis gets more complex. Thus, both criteria 3 and 4 were constraints to adoption and farmers eliminated ‘production cost’ if they passed neither criterion 3 nor criterion 4 altogether. This was the case of farmer 11, who claimed he did not know how to work out non-cash costs (criterion 3), although he had an overall understanding of what these costs refer to. He did not have qualified staff to support such a detailed analysis (criterion 4) and thus, ended up controlling cash costs only (i.e., ‘simple controller’). Like some previous cash cost controllers, farmer 11 also had different accounts for beef and crop records and worked out beef unit costs per paddock (e.g., cash cost/ha of cattle on paddock 1). Similarly, farmers 21 and 27 did not know how to work out beef costs (criterion 3) but both had specialised staff to carry out this analysis (criterion 4) and consequently 'went back' to criterion 5, joining the other 15 farmers.

From 17 farmers who went through criterion 5, six believed there were no depreciation costs and worked out cash costs only. Unlike previous farmers who eliminated non-cash costs pre-attentively (i.e., with no further elaboration), farmers 02, 05, 15, 17, 21 and 24 (simple controllers) did not consider depreciation (a non-cash cost) because they believed maintenance costs replace depreciation costs. In their view, as they maintained their assets, they had their lives constantly extended and thus, did not depreciate. The inclusion of depreciation would result in double counting, in their opinion.

These six farmers controlled cash flow (i.e., monthly balance), whereas other cash cost controllers relied mainly on expenditure reports (i.e., total spent a month). Farmer 02, who had a diversified farm, had different accounts to record beef, tourism and personal expenditure and revenue. Farmer 24, who also had on-farm diversification, controlled the complete cash flow of all farming operations. Additionally, he worked out several unit costs such as cost/head, cost/ha and cost/30 kg of liveweight (the so-called, *'arroba'*).

The 11 remaining farmers, who went through criterion 5, formally included depreciation costs in their cost analysis as they believed farming enterprises, including beef, must account for the cost of replacing assets at the end of their productive life. These farmers went down to criterion 6, where they split into two outcomes, according to their views on opportunity costs (a non-cash cost): four farmers ('advanced managers'), for whom criterion 6 was important, took the left path, making the decision of working out total production costs, including both cash and non-cash costs; seven farmers, for whom criterion 6 was irrelevant, took the right path, with six deciding to work out operational costs (cash costs plus depreciation), the so-called 'operational managers'. Farmer 30 was somewhat puzzling. Despite asserting that non-cash costs were important to the farm management, this farmer claimed he would give up farming if he included all these cost components in his analysis as the farm would be unprofitable. As a consequence, he controlled cash costs only while the model suggested he was working out operational costs. This means the model did not capture this farmer's decision path given his idiosyncratic views. Perhaps, he had a decision criterion that was not apparent and was not elicited. In addition to controlling cash flow, farmer 30 ran investment analysis.

Farmers 03, 18, 19, 27, 31 and 34, who worked out operational costs ('operational managers'), were not convinced about the appropriateness of opportunity costs of capital as an indicator for decision-making, particularly when land is considered. They believed if opportunity costs were included their farm would be considered unprofitable, suggesting they should consider selling the property. However, this was not consistent with their actual perception that their farms were profitable. This perception was based on the fact that they have been able to *"pay their bills"* and, in most cases, also improve the farms. Moreover, they claimed they have had capital gains on land over the years and selling the farm would be inappropriate.

Despite sharing some views, the six 'operational managers' had varied cost control systems. Farmer 03 paid himself a wage and this expenditure was included in a cash flow prepared monthly. Additionally, he had an annual budget where estimated and realised expenditure were compared on a monthly basis. Once a year, he worked out margins, including depreciation costs. Farmers 18, 19, 27, 31 and 34 also controlled the cash flow monthly and worked out margins annually, including depreciation costs. Furthermore, farmer 19 considered the variation of cattle inventory and the opportunity costs of administration; the latter referred to farmer 19's father's wage for helping with the farm management. Annually, when calculating total operational costs, farmers 19, 27, 31 and 34 worked out unit costs such as cost/head and operational costs/head. In addition to the cost analysis, farmer 27 carried out investment analysis, when necessary.

In contrast with the previous group, farmers 06, 09, 23 and 26, who worked out total beef costs ('advanced managers'), believed the inclusion of cash and non-cash costs were important at a strategic management level for providing farmers with a broader view on their businesses performance. They all controlled the cash flow and included depreciation and opportunity costs when working out margins. Unlike the majority of the previous farmers, who withdrew cash from the farm account whenever needed, farmers 06, 09 and 26 paid themselves a monthly wage. The exception was farmer 23, who had the farm sponsoring his personal expenditure without having a limit established. However, *"to know how much income the farm supports"* was a major motivation for farmer 23 to further develop his cost control system. Hence, he was hopeful to establish a withdrawal limit in the near future, based on preliminary cost results.

As farmer 23 illustrated, the level of sophistication of the cost control system was dependent upon farmers' level of expertise in this subject which determined the stage of development of the cost system. Farmer 23 had recently implemented a computerised cost control system and was learning how to organise and record different cost components. Thus, despite considering all cost components, the reports were still simple. He split the farm expenditure into beef and administration accounts; the latter also included his personal expenditure. Farmers 06, 09 and 26, in contrast, have developed their cost control system over many years. Farmer 26 has been controlling cash costs for more than ten years and kept different accounts for beef and administration expenditure. He recently upgraded his system to account for non-cash costs, and determine total production costs. Farmer 06's cost system has also been settled for a few years being based on his off-farm experience. He put in place a detailed cost control system. His staff provided him with several monthly financial reports, including both operating costs (cash cost) and investments; annually, they worked out total costs of production reporting all cash costs, depreciation and opportunity costs on capital, excluding land. Land was excluded because, in this farmer's view, *"opportunity costs on land are inappropriate* (...) *as land has capital gain"*. Farmer 09's cost control system was fully implemented in 2004 and had the most sophisticated financial management system of all interviewed farmers. He meticulously organised accounts to register different sources of expenditure (e.g., beef, crops, sugarcane and administration). Administration costs were shared among enterprises according to allocated land area. He worked out total production costs, several unit costs (e.g., costs/ha, costs/sold cattle and costs/produced cattle) and capital position measurements, such as a net worth statement and the net capital ratio. Additionally, he established a policy for investments based on a percentage of annual gross margins. Such a thorough cost analysis stemmed from this farmer's intrinsic and extrinsic motivations. Intrinsically, his motivation was the enjoyment obtained from analysing his farm performance, 'playing' with the figures and benchmarking, as he reported. His extrinsic motivation related to his business partners' (i.e., his siblings) requirement for a thorough annual report of the farm's technical and financial performance.

Similarly to the cattle supplementation model, farmers faced criteria that would make them change their decisions, through the 'unless conditions' (UC), identified by letters in the model (Figure 8.3). Intuitive farmers 13 and 14 would consider more detailed cost analysis if there were business partners they had to report to (UC 'a'). This was the case of farmer 31, whose brother was a partner in the farm and motivated him to further develop his control and analysis systems. Farmer 2, who controlled cash costs only, would run a more detailed cost analysis if he had several farms or several on-farm enterprises (UC 'b'). In contrast, other farmers, such as 03 and 23, would discontinue working out detailed production costs if it becomes harder to calculate or if data collection and analysis become too time consuming (UC 'c').

In general, the decision tree model (Figure 8.3) showed that many farmers were uncertain on the benefits of including non-cash costs in their cost analysis. They thought it was a sophistication they were neither willing nor prepared to implement. Given criteria in the decision tree model were slightly changed into higher order criteria (i.e., more synthesised), Tables 8.4 and 8.5 show the specific decision criteria mentioned by farmers during the interviews. Consideration is given to these specific criteria because they provide additional insights on these farmers' reasoning for non-adoption or partial adoption of 'production cost analysis'.

Table 8.4 Reasons for not considering depreciation costs among 24 farmers (non-adopters and partial adopters)

Decision factors	No.	%
A. Maintenance is included in the cost	9	37
B. Limited machinery so it is irrelevant	3	12
C. Small infra-structure so it is irrelevant	2	8
D. Old machinery is depreciated already	1	4
E. Depreciation is accounted for in the lease contract	1	4
F. The farm would be unprofitable	1	4

The main reason for not including depreciation costs was the farmers' belief that maintenance replaces depreciation, as discussed earlier for criterion 5 in the decision model (Figure 8.3). Farmers 02, 05, 08, 11, 15, 17, 21, 22 and 24 all shared this belief, although farmers 08, 11 and 22 did not go through criterion 5 as they took alternative paths earlier in the model. Other farmers found depreciation irrelevant and disregarded it because they had little machinery (farmers 02, 08 and 15), old machinery that was already depreciated (farmer 10), a small infra-structure (farmers 04 and 07), or because including depreciation would make the farm look unprofitable (farmer 30). Farmer 32, who leased his farm, argued depreciation was included in the lease contract. Interestingly, most farmers' comments on depreciation referred to machinery rather than buildings and infrastructure, suggesting depreciation on infrastructure was not considered (i.e., eliminated pre-attentively). Arguably, the longer productive life of infra-structure relative to machinery led farmers to overlook this cost component.

Farmers also had various, often combined, reasons to not accounting for opportunity costs in their production cost analysis. The reasons mentioned by 22 non-adopters and partial adopters of cost analysis are reported below (Table 8.5).

Table 8.5 Reasons for not considering opportunity costs among 22 farmers (non-adopters and partial adopters)

Decision factors	No.	%
A. It overlooks capital gains	11	50
B. Opportunity cost is misleading	9	41
C. The farm would be unprofitable, if it is included	6	27
D. Usefulness is doubtful	4	18
E. Not applicable as the farmer would not do something else	4	18
F. There is no intention to sell the farm	3	14

Several farmers (02, 05, 07, 08, 11, 15, 17, 21 and 25) believed opportunity costs were misleading as a performance indicator since it would suggest they sell their farms. Also, farmers 02, 03, 05, 06, 08, 10, 11, 15, 17, 19 and 25 found it contradictory that while cost analysis, including opportunity costs, would suggest they were operating at a loss, they were actually accruing capital gains. This apparent loss was also inconsistent with their overall perception of being able to *"pay their bills and improve the farm"*. Farmers 02, 03, 05 and 18 were unsure about the usefulness of opportunity costs as they did not see how this cost component would improve their decisions. For farmers 04, 10, 11, 17, 18 and 19, the inclusion of opportunity costs, particularly on land, would suggest their farms were unprofitable, which they disagreed with. Other farmers' reasons for ignoring opportunity costs included the wish to keep their farms (farmers 04, 24 and 25) so they believed there was no reason to compare the actual capital use with an alternative investment (i.e., as *per* opportunity costs definition). Similarly, farmers 11, 17, 21 and 24 argued that there was no opportunity cost for their capital and own administration because they would consider doing nothing else.

8.3 Comparative Analysis of Decision Making Processes on Production versus Managerial Technology

In the previous section, ethnographic decision tree models (Figures 8.1, 8.2 and 8.3) described several combinations of decision criteria leading farmers to various outcomes. These criteria in general related to farmers' diverse objectives, beliefs, perceptions, resources, experience and knowledge. The result was a large diversity of technology adoption behaviours among innovative beef farmers over both a production and a managerial technology.

In the next two sub-sections, these criteria are analysed on the basis of the models' structure and cognition so that similarities and differences are identified. Farmers' constructs on cattle supplementation and cost analysis are also assessed to determine whether farmers construed different types of technology differently.

8.3.1 Tree models' structure

The overall structure of the decision tree models was similar to the structure of decision trees found in other studies (Fairweather, 1992; Fairweather & Campbell, 1996; Gladwin, 1989; Jangu, 1993). Here, decisions were both made in two stages: elimination-by-aspect stage and *"hard core"* stage (Gladwin, 1989, p. 20). Within the first stage of decision-making, farmers passed some elimination criteria before considering adoption decision in any detail. During this stage, these technologies were eliminated rapidly (i.e., pre-attentively) or as a result of barriers to adoption. Only farmers who passed the first stage seriously considered the technology adoption. The models then identified several motivations for adoption and non-adoption behaviours of both technologies. However, having decided to adopt, this was not necessarily carried through as any one of a number of constraints would limit farmers' ability to pursue the behaviour. The main constraints were reported in both models using 'unless conditions', as suggested by Gladwin (1989). Interview data, however, revealed that these farmers would change supplementation decisions if any of several hypothetical reasons applied and not only because of the main 'unless conditions' reported in the model. These 'unless conditions' were reported separately (Tables 8.2 and 8.3) to provide further insights on the farmers' decision making process. This procedure was not necessary for the decision model on cost analysis given its conciseness, which resulted from the small number of decision criteria mentioned by farmers as well as some criteria aggregation previously undertaken.

Another difference between the decision models was the number of criteria involved in each decision. The adoption decision on cattle supplementation comprised a total of 18 criteria (Figures 8.1. and 8.2) whereas the decision on production cost analysis involved only six criteria (Figure 8.3). Although the conciseness of the cost decision model resulted, to a small proportion, from the synthesis undertaken for some criteria, it is mainly explained by the farmers' lack of eloquence when discussing this technology. Theoretically, the 'longest' decision path involved 14 criteria for the supplementation decision and five criteria for the cost analysis decision. Empirically, individual farmers went through no more than 11 criteria to decide on supplementation or five criteria to make a decision on cost analysis. In both models, farmers 'passed by' some decision criteria that they were not necessarily conscious of, as criterion 2 of the supplementation model (Figure 8.1) exemplifies: having the philosophy of running the farm under a low input or more natural system was a determining factor on farmer 02's adoption behaviour, but it was not taken into account by other farmers who 'went down' the tree model.

The above comparison between the models' structure showed that these innovative farmers followed similar steps when making decisions on different technologies, passing elimination and constraints aspects first and then considering motivations for adoption and non-adoption. The comparative analysis also highlighted a major difference between the models: their 'size'. The reduced number of criteria for the decision model on cost analysis revealed farmers made this decision more concisely than the decision on cattle supplementation. The 'size' of each model to some extent reflected farmers' level of understanding of, and possibly preference for, each of the two technologies. For instance, when farmers were explaining their cattle supplementation strategies, they were enthusiastic about it, wanted to show the associated infrastructure and provided detailed information about feedstuff nutritional value, the interaction within the animal-plant-environment, and supplementation costs. In contrast, most farmers had to be prompted to talk about cost analysis. Often, their comments were vague and brief with a quick shift back to technical issues.

8.3.2 Tree models' cognition

In order to determine whether innovative farmers used different constructs to decide on the adoption of the two technologies being studied here, the decision models presented in Sections 8.2.1 and 8.2.2 were analysed from a cognitive perspective.The type and nature of both technologies were also given consideration, as other results presented in this chapter suggested these are relevant in the context of this research.

The analysis of decision criteria in the ethnographic decision trees (Figures 8.1, 8.2 and 8.3) revealed that farmers' goals and values provided the framework for decision making in both models. For instance, farmers who wanted to improve production or productivity tended to supplement cattle, unless they believed it was less economically viable than other alternatives (Figure 8.2). In contrast, farmers concerned with production sustainability leaned towards exclusive grazing systems, supplementing cattle only if extremely necessary (Figure 8.1). Farmers' goals also drove decision paths in the cost analysis model (Figure 8.3), although not explicitly. Farmers who wanted to run the farm as a business and to *"know where their money was going to"* put in place some level of cost analysis. The level of sophistication of such analysis was not only influenced by farmers' understanding of cost components but possibly by their personal values: those who valued meticulous control over the farm tended to have more detailed cost analysis whereas those whose preference was for an easy and simple approach tended to have a basic cost analysis or no cost control at all.

Another outstanding observation from the comparison was the lack of production and profit related criteria in the cost analysis model (Figure 8.3). While some of these criteria were not applicable to cost analysis (e.g., criterion 8, Figure 8.2), other criteria, at least in theory, could have been applied to this decision adoption model. An example is net returns (criterion 15, Figure 8.2). This suggests that most farmers, when making decisions on a cost analysis system, saw no relationship between the adoption of this technology and the possibility of increasing profits and/or production. This finding is strong evidence to explain the low adoption rate of cost analysis (Chapter 7).

The type of technology (e.g., production versus managerial) and the resulting outcomes from its adoption provided some explanation as to why most farmers did not construe cost analysis using production and profit-related criteria. The adoption of the production technology (cattle supplementation) impacted directly on cattle liveweight and/or the farm profitability while the managerial technology (analysis of beef production costs) provided farmers with information in contrast to physical output. Unless this information is understood and properly used to support farm management, and increase the farm production and/or profit, it is useless *per se*. Hence, the value of information is subjective and, ultimately, depends on farmers' understanding of its content and perceptions of its usefulness. Farmers who perceived a detailed cost analysis as irrelevant did not adopt it because they could not link this technology to any direct benefit. Only those who believed opportunity costs were relevant for the farm strategic management (criterion 6, Figure 8.3) found a detailed cost system useful for enhancing the farm performance.

Along with the type of technology, its nature (i.e., 'hard' versus 'soft') also influenced farmers' perceptions of a technology and the selection of decision criteria. Both decision tree models (Figures 8.1, 8.2 and 8.3) included physical (i.e., 'hard') and conceptual (i.e., 'soft') decision criteria. Examples of 'hard' criteria were capital availability (criterion 6, Figure 8.1) and qualified staff to work out costs (criterion 4, Figure 8.3) whereas farmers' experience on supplementation (criterion 4, Figure 8.1) and their beliefs on the benefits of cost analysis to the farm strategic management (criterion 6, Figure 8.3) illustrate 'soft' criteria.

The prevalence of physical and conceptual criteria differed considerably between the models, however. In the supplementation adoption model (Figures 8.1 and 8.2), decision criteria were predominantly physical whereas in the cost analysis model, conceptual criteria prevailed. Most physical decision criteria, such as agro-climatic constraints and lack of capital, were not applicable to the cost analysis decision because of its 'soft' (e.g., conceptual) nature. Physical criteria could have played a more relevant role in this decision if farmers associated the adoption of cost analysis to the prior adoption of a ‘hard’ technology, such as the use of a computer or the purchase of financial software (i.e., ‘hard’ managerial technology). However, this was not the case as farmers treated the adoption of both ‘hard’ managerial technologies separately (i.e., they belonged to a different decision tree model).

The above results suggested that there was a strong relationship between the nature of technology and the nature of criteria selected for decision-making. Adoption decisions on the ‘hard’ technology used predominantly physical (i.e., ‘hard’) decision criteria whilst the decision on the ‘soft’ technology was largely based on conceptual (i.e., ‘soft’) criteria. Moreover, it seems that the nature of technology was more important than the type of technology in the selection of decision criteria, as discussed above. Other empirical data from farmers’ interviews supported this claim. For instance, the adoption of a traceability system, a ‘hard’ managerial technology, included ‘hard’ criteria such as returns on investment, premium price and production levels (see farmers 05, 08, 18 and 26, Appendix G). In contrast, mating season, a ‘soft’ production technology, was mostly construed by farmers in terms of ease of cattle handling and better organisation of the workforce (i.e., conceptual criteria).

Overall, it does seem farmers mostly used different decision criteria to assess a ‘hard’ production and a ‘soft’ managerial technology. However, different decision criteria may originate from the same construct. For example, criterion 4 in the supplementation decision model (Figure 8.1) and criterion 3 in the cost analysis decision model (Figure 8.3) were both associated with the construct ‘knowledge’. Thus, the analysis of solely decision criteria is not sufficient for drawing conclusions on how differently farmers assess technologies unless their constructs are further investigated.

Using the principles of the Personal Constructs Theory, constructs were elicited by the researcher’s assessment of the farmers’ decision criteria in the decision models. This strategy was undertaken because the RepGrid software was dropped during the pilot test. Assuming that the elicitation of aspects, or constructs, related to technologies is similar to that of decision criteria (as discussed in Chapter 3), it is possible to find an overlap between these concepts. Constructs are structures of meaning, in which one’s mental processes run. They are bipolar abstractions (e.g., easy versus difficult) that people use in order to make sense of the world and construe reality. Decision criteria, in turn, are a particular case of constructs, i.e. their articulation within a specific context. Thus, it is possible to determine the superordinate constructs related to each decision criterion, allowing for direct comparisons between the decision models. In this study, the analysis of farmers’ constructs on cattle supplementation and cost analysis were inferred from the ethnographic decision tree models. All constructs identified in the models for these two technologies are presented in Table 8.6 along with their associated decision criteria (in brackets), based on Figures 8.1 to 8.3.

Table 8.6 Farmers' constructs and associated decision criteria

Constructs[1]	*Criteria from the supplementation model*	*Criteria from the cost analysis model*
Compatible x Incompatible	(1); (2)	(1)
Feasible x Not-feasible	(8); (18)	(5)
Knowledgeable x Ignorant	(4)	(3)
Need support x Do it myself	(5); (16)	(4)
Relaxed x Short of cash	(6); (7)	-
High x Low animal production/ productivity	(3); (10)	-
High x Low land productivity	(9); (13)	-
Economic benefit x Loss	(11); (15); (17)	-
Easy x Hard	(12); (14); (16)	(8.3.c)
Costly x Affordable	(12); (14)	N.A.
Relevant x Irrelevant	(18)	(1); (2); (8.3.a, b)
Strategic x Operational Management	-	(6)

1. Decision criteria are in brackets; the 'unless conditions' of the tree model on cost analysis (Figure 8.3) are identified by letters; 'N.A.' stands for 'Non-applicable'; '-' indicates constructs that are in theory applicable, but were not considered by these farmers.

In general, there was some overlapping of constructs between the two decisions, particularly during the first stage of the decision making process. This indicated that, during the elimination-by-aspect stage of decision making, cattle supplementation and cost analysis were mostly assessed through the same constructs. Constructs that were considered in both decisions included compatibility, relevance, knowledge and skills.

Besides some shared constructs, other constructs varied accordingly and were used to construe one technology but not the other. This was the case of constructs that were not applicable to one of the technologies, such as the 'affordability' construct, or constructs that, although theoretically applicable, were not considered as such by farmers. The 'strategic x operational management' construct, for instance, was used for construing cost analysis but not cattle supplementation. On the other hand, constructs used for construing supplementation but not cost analysis related to production and economic benefits. This lack of production and profit related constructs was a consequence of the absence of their associated decision criteria, as discussed previously. Therefore, the missing constructs in one of the models indicated that these innovative beef farmers did not construe cost analysis like they construed cattle supplementation. This was particularly evident for constructs used during the second stage of the decision making process, suggesting farmers had different motivations to adopt (or not) cattle supplementation and cost analysis.

In summary, farmers' decision trees were more elaborate for cattle supplementation than for cost analysis as a result of their level of proficiency in each of these two technologies. Moreover, decision criteria varied in type and nature, according to the type and nature of the technology. As a consequence, constructs also varied for the two technologies, particularly those associated with motivational decision criteria. There is strong evidence to suggest innovative beef farmers construe different technologies differently.

8.4 Other Factors Influencing on Technology Adoption and Non-adoption Behaviours

Results from the previous sections showed that decision-making processes are complex and involve several factors. Apart from farmer 30's idiosyncratic views, farmers' adoption decisions were all rational within the limits of their understanding of each of the two selected technologies. The more elaborate decision model for cattle supplementation, compared to the cost analysis model, indicated they were aware of many factors relevant for the production-related decision, but not for the managerial decision. This partly explained the higher adoption rate for the former than for the latter. The understanding of, and passion for, production issues is usually a natural vocation of farmers; a culture that is shared by generations. Managerial technologies, in contrast, are something they have more recently been learning to deal with and to respond to increasing competitiveness and margin reductions in the beef sector.

This learning process and its influence on adoption were captured by the decision tree model on cost analysis, in which the outcomes allowed for non-adoption, partial adoption and full adoption. The better understanding a farmer had of this technology, the more likely he was to upgrade the system and adopt a more sophisticated analysis of costs. Within the decision tree, this means that farmers who were more proficient in cost analysis usually went further down the paths than those who had a superficial understanding of cost components and therefore reached an outcome earlier in the model (i.e., adopted simpler cost analysis systems). Some evidence was provided by farmers 23 and 26, who, like others, had upgraded their systems because they had been to training courses and were learning about cost analysis. A counterpoint, though, was that this observation may not be valid for all types of farmers as some older farmers, like 12, 13 and 20, who did not analyse beef costs, were unlikely to change their approach at this stage. As farmer 13 claimed, he *"started [farming] sharing a* *tractor and now has more than 8,000 hectares"*, so he believed he was *"doing very well"* without controlling costs.

Arguably, educational causes on adoption might have occurred for the cattle supplementation decision. Farmer 8, who had started farming three years prior to the interview, provides an example. He was learning about supplementation and had unsuccessfully tried supplementation in the previous year. He acknowledged, however, his pasture was overgrazed and might have limited the outcome of supplementation. So, despite being unsure about the results, he declared he was going to try it again. This example shows this farmer's behaviour shifted from non-adoption in the first year to partial adoption in the following year, as he learned about supplementation, and suggests he may fully implement it in the future. However, the decision tree model did not capture this dynamic because supplementation adoption was treated dichotomously (i.e., adoption versus non-adoption) and farmer 08 was a non-adopter. Additionally, the tree model was a snapshot of farmers' decision to supplement cattle in the previous dry season and, as such, did not allow for the dynamic elements associated with learning to be incorporated in the model.

Adoption was also affected by farmers' perceptions on how each technology fitted within their farming systems, which were set up based on their prevailing goals and values. This result suggests that farmers' goals and values influenced adoption decisions indirectly by providing a context for decision making. Other criteria, however, affected decisions more directly. As discussed in the previous sections, these criteria varied across decision models and across farmers within a particular decision model. Farmers who 'went down' the same path within a decision tree model (i.e., used the same decision criteria), reached the same outcome and construed that particular technology similarly. In contrast, farmers who 'went down' different paths within a decision tree model construed that particular technology differently from other farmers, although they could have reached the same decision. This result suggests that individual farmers who adopted a particular technology might have had different motivations for doing so; the same applies to farmers who did not adopt a technology.

The findings also revealed that the non-adoption decision was as rational and elaborate as the adoption decision and not simply a lack of adoption or a conservative approach to farming. Four situations were found to stop farmers from adopting cattle supplementation and/or cost analysis: (1) the technology was incompatible with farming goals and systems; (2) the technology was perceived as irrelevant to the current production system; (3) there was a constraint on adoption; and (4) there was a better alternative than adopting this technology.

Although it is acknowledged constrained farmers might have passively accepted non-adoption, having a constraint did not automatically preclude farmers from giving some consideration to adoption. In general, most non-adoption behaviour had farmers engaged in an elaborate decision making process, which led them to deliberately take a particular course of action; in this case, non-adoption.

8.5 Summary and Conclusions

In chapter 8, innovative farmers' adoption and non-adoption of two contrasting technologies were investigated to address research question three: 'Do innovative beef farmers use a different set of constructs when assessing different types of technologies? If so, why?' Initially, farmers' adoption and non-adoption of cattle supplementation (a 'hard' production technology) and cost analysis (a 'soft' managerial technology) were mapped and compared, but no major association was found between the adoption behaviour related to these technologies. Some patterns were noticed, though, between adoption behaviour and the farmer types developed in Chapter 6. In general, farmers within the same type (i.e., factor) tended to have similar adoption behaviours.

To assess why farmers took a particular course, ethnographic decision trees were developed for both cattle supplementation and cost analysis. Several decision criteria were identified, with the main ones being included in the decision models. Farmers who 'went down' the same path within a tree model construed that particular technology similarly, whereas those who 'went down' different paths had various constructions of that technology. The models also showed that adopters of a technology might have reached such a decision through various paths, which means they had different motivations for adoption. Likewise, the reasons for non-adoption varied among non-adopters of a particular technology.

When the two decision tree models were compared (Section 8.3), the results suggested that farmers generally used different decision criteria for the cattle supplementation in comparison to the cost analysis decisions. Moreover, it was found that the type and nature of the technology influenced the selection of these criteria. Cattle supplementation, a 'hard' production technology, was mostly assessed through 'hard' decision criteria, usually related to production and economics (i.e., farm performance). In contrast, cost analysis, a 'soft' managerial technology, was mainly construed by 'soft' decision criteria. Additionally, farmers did not associate this technology with the farm performance and established basic levels of financial control to cope with tax regulations and to avoid being in debt (i.e., financial risk).

A consequence of the differences among decision criteria for the two technologies was that farmers' constructs varied and farmers generally construed the production and the managerial technologies differently. These differences were more noticeable during the second stage of decision making. This suggested that farmers tended to use similar constructs to eliminate technology rapidly but had different motivational-related constructs to decide on adoption during the second stage of the decision making process.

The farmers' level of understanding about each of the two technologies proved to be relevant not only for construing the technologies but, more importantly, to determine whether the technology was relevant, suitable and feasible to their farming systems. By implication, as farmers got more proficient, they moved towards more advanced production and managerial practices.

Finally, the models showed that, irrespective of the final decision (either adoption or non-adoption), most farmers undertook a thoughtful process, considering several criteria along the way. This suggests that both adoption and non-adoption were rational, given the farmers' level of knowledge and constraints.

Chapter 9
Discussion and Concluding Remarks

9.1 Introduction

In the last three chapters, results from this study were presented and some initial discussions pertinent to each chapter were carried out. In this chapter, all the findings are brought together into an integrated discussion and the main emergent themes associated with technology adoption explored relative to other adoption literature. The literature review presented in Chapters 2, 3, 4 and parts of Chapter 5 provides the framework for the following discussions.

This chapter starts with a discussion of the factors that explain **why** innovative beef farmers make adoption and non-adoption decisions they way they do. These include some background information, farming orientations, social influences and the technology attributes. Emphasis is given to the diversity of goals and values of innovative farmers. Next, the discussion turns to **how** innovative farmers make adoption decisions, highlighting the process of decision making itself. The main conclusions are drawn, followed by a discussion on the theoretical and the practical implications of the findings. Subsequently, attention is given to methodological issues, including a comparison between the Q-methodology and the Ethnographic Decision Tree Modelling. Finally, some limitations are considered and future research directions suggested.

9.2 Factors Affecting Farmers' Adoption Decision Making

Several factors affecting adoption identified in earlier chapters are brought together in this section, including farmers' innovativeness, the farm and farmers' characteristics, farming orientations, the social milieu and the technologies attributes. The main findings are discussed in the light of existing literature, drawing attention to the contributions of this research to this body of knowledge. The implications of the findings are further explored later in this chapter.

9.2.1 Farmers' innovativeness

Through farmers' accounts of their approaches to farming, it was clear that innovativeness manifested in two ways: (1) technology adoption behaviour; (2) creation and adaptation of farming practices. The adoption dimension of innovativeness became evident through the analysis of farmers' technological profiles (Appendix I): the higher adoption of technologies, the more innovative a farmer was. Given the overall high technology adoption rates, these innovative farmers were generally open to new ideas and held a positive attitude toward innovations.

The second dimension of innovativeness (creativity) emerged throughout farmers' interviews. The more inventive, the more innovative a farmer was. Farmer 11, for example, was a pioneer in cattle-crop integrated systems (CCIS), developing several CCIS strategies through different combinations of crops, in different seasons and within various land rotation schemes. Because of his vast practical experience, he became a reference for other farmers and researchers, who often visit his farm to learn about his farming system, including CCIS (see details in Appendix G). However, the development of technologies by farmers themselves was limited to a small group of farmers. More common was the adaptation of research-based technologies to local farming condition, which was also an expression of their innovativeness.

Another cue of the double dimension of innovativeness was farmers' responses to statements 05 and 47 of the Q-sort, presented in Chapter 6. For instance, farmers from the Committed Environmentalist (CE) type were not interested in adopting technology as much as possible, but were highly motivated to innovate. This apparent paradox indicates that the CE farmers were thinking of innovativeness as *"doing things differently"*, which they were keen on, but not necessarily solely through the adoption of technologies.

The two dimensions of innovativeness found among the surveyed innovative farmers support and extend Hurley and Hult's (1998, p. 44) definition of innovativeness: *"it is a notion of openness to new ideas"*. While the authors originally focused on a firm (i.e., firm innovativeness) and referred to the firm overall culture of innovation, this study provided some evidence that it also applies to individuals; in this case, beef farmers. By implication, the understanding of innovativeness proposed here goes beyond Rogers' (2003, p. 280) proposition that innovativeness is *"the degree to which an individual (...) is relatively earlier in adopting new ideas than other members of the social system"*.

While Rogers' (2003) proposition is useful to understand the diffusion (i.e., aggregate adoption rate) of a particular technology, it provides a fragmented and simplistic view of decision makers themselves. By defining innovativeness in that way (above), Rogers (2003, pp. 282-285) assumed that technology is inherently good and adoption is just a matter of time (i.e., pro-technology bias). In his theory, innovators and early adopters are the people with a vision, or the real innovative people, whereas the late majority and the laggards are sceptical and traditional, respectively. Furthermore, in Rogers' propositions there is no 'non-adopter' category, which reinforces the foregoing argument of a pro-technology bias. However, the application of Rogers' five categories of adopters (representing the degrees of innovativeness) to this study, for instance, would indicate that farmers are simultaneously early adopters, late adopters or even laggards for different technologies, which is a little puzzling when it comes to explain adoption behaviour in general. This occurs due to the unit of analysis being the technology rather than the farmer.

In this study, though, technologies are used as means to enhance the understanding of farmers' overall adoption behaviour. An assessment of the adoption of cattle supplementation and cost analysis in Chapter 8, for instance, showed that beef farmers who did not adopt one or another technology had a rational justification for non-adoption and it had little to do with their degree of innovativeness. These justifications included a constraint and an incompatibility of the technology to the farming system, among others. This result indicates that non-adoption does not necessarily mean a low degree of innovativeness. The suitability of the technology and, as Hurley and Hult (1998, p. 45) propose, the capacity to adopt are also relevant for the adoption behaviour. Furthermore, results suggest that innovativeness includes both adoption and non-adoption as farmers strategically selected the technologies that fitted and enhanced their farming systems.

The discussion above provides evidence for innovation as a process that goes beyond technology adoption and includes non-adoption, creation and adaptation of technologies as well as farmers' capacity to adopt. In this context, being innovative is not a synonym of being an adopter of technologies. Rather, it means being open to new ideas, and perhaps being creative, while pursuing a 'suitable' balance between adoption and non-adoption of specific technologies. This concept is significantly different from prevailing ideas of innovativeness that are bonded with the use of technologies, such as those found in Rogers (2003). By incorporating non-adoption, it also expands Shumpeter's (1934) definition of the innovation process with its five dimensions, including the introduction of new goods or new methods. Whether farmers lean more towards adoption or non-adoption is an approximation of their level of innovativeness.

9.2.2 Farm and farmers' characteristics

Given the sampled farmers were selected for being innovative, the analysis of their profiles (Appendix G) provides some insights on the characteristics associated with innovativeness. Innovativeness spanned a range of farm and farmer's characteristics. Innovative farming systems included both exclusive beef systems (commercial and/or high genetics herds) and highly diversified farms. Innovative systems also spanned across beef production systems, covering cow/calf, rearing and fattening phases, solely or combined. There was also diversity of herd sizes (and farm sizes, thereof) among innovative beef farmers; yet, it is not possible to determine whether large and small beef enterprises are equally innovative given a sampling bias as the inclusion of small, medium and large herds was one criterion to select these innovative farmers.

Innovativeness also occurred across all sampled farmers to a greater or lesser extent, irrespective of their age. Despite being statistically non-significant to explain farmers' overall adoption rates, age seems to have affected farmers' prevailing goals and thus, indirectly influenced the adoption of particular technologies. This was indicated by the conjoint analysis of the farmer types (Chapter 6), the adoption rates of technologies (Chapter 7) and the decision trees (Chapter 8). It appears that differences in prevailing goals related to the farmers' age since there was an 8-year gap among the farmer types, except the Committed Environmentalist (CE) and the Professional Farmer (PF) who had the same average age. This means that younger farmers tended to have different objectives than older farmers. To fulfil their objectives, these farmers, represented by farmer types, tended to prioritise different types of technologies (production, managerial and environmental). For instance, the Aspirant Top Farmer (ATF), which consisted mostly of young farmers, tended to focus on managerial technologies whereas the Profit Maximiser (PM) was into production technology. This was further confirmed by the ethnographic decision tree model on cost analysis (Figure 8.3, Chapter 8). Farmers in ATF type (mostly young farmers) adopted more elaborate cost analysis than those from the PM type, who were older. Also, older farmers within the PF type tended to have no or only basic control of costs.

Having an off-farm business tended to support the farmers' innovativeness in two ways: (1) by widening their social interactions and networking; and (2) by enabling the incorporation of business practices from their non-farming businesses into farming systems. It also allowed, in some cases, for the financing of farming operations and on-farm investments, facilitating technology adoption. However, it was not clear if non-adoption among farmers with no off-farming activities was due to limited access to external funding sources or because of them being less innovative than the other farmers given their limited access to (1) and (2) above.

While innovativeness occurred across different farm types and farmers, it seems that education was consistently an important factor associated with innovativeness. Several studies have shown a positive effect of education on technology adoption (Dimara & Skuras, 2003; Gillespie *et al.*, 2007; Ward *et al.*, 2008), which this study corroborates. The vast majority of the sampled beef farmers were tertiary educated, usually in agriculture-related degrees, with some also holding a masters degree. This may have influenced the high average adoption rate of 60 percent of all applicable technologies in this study while also explaining the difference in adoption levels between these innovative beef farmers and Brazilian average farmers[19] (shown in Chapter 7). Formal schooling facilitated the pursuit of innovative farming systems in three major ways: (1) it provided farmers with a formal knowledge on farming systems and management, making it easier to understand or develop new technologies; (2) it enabled social interactions with academia, improving farmers' network; and (3) it created an opportunity for off-farm work. The importance of the latter was discussed previously.

However, being less educated did not preclude other farmers from being innovative. Farmers with primary and secondary education all stopped studying to help their parents on the farm. Since they were also the oldest farmers, most had over 30 years of farming experience. Over this period, they have gone successfully through several changes in the Brazilian political-economical and social systems, which allowed them to develop adaptive skills and to become resilient. This suggests that the development of adaptive skills and farmers' informal knowledge are also important factors for innovativeness. Whether these factors will be sufficient for the next generations to prosper is questionable given the fast changing environment for farming.

The processes of knowledge building, both formally and informally, and skills development relate to farmers' learning processes (Marra *et al.*, 2003; Nuthall, 2001, 2006), which are also relevant to innovativeness. All of the 26 innovative farmers were constantly seeking information and improving their beef systems, which means that farming was a continuous learning process. Given their various levels of farming experience, they were at different stages of the learning process, which impacted upon their farming systems. In general, experienced farmers had relatively stable farming systems, with most adjustments being fine tuning. In contrast, among less experienced farmers such as farmer 8, the farming systems were less stable because farmers were more often experimenting with technologies, with farming systems oscillating accordingly. By experimenting with technologies, these farmers learned about their *pros* and *cons*, adjusted their expectations of future outcomes and reduced the risks associated with adoption, as suggested by Marra, Pannell and Ghadim (2003). As farmers got more knowledgeable, they moved towards stable farming systems.

Farmers' experimentation with technologies is consistent with Kelly's (1955) proposition that ordinary people act like scientists when trying to make sense of the world and engage in

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[19] The Brazilian Agricultural Census in 2006 showed that only three percent of farmers, including beef farmers, have tertiary education, with the degree being often non-farming related (IBGE, 2006, pp. 178-181).

behaviours to test their expectations, like scientist run experiments to test their hypotheses (see details in Chapter 3). In particular, it reinforces Kelly's *"experience corollary"* which proposes that people constantly reconstrue events on the basis of learning from experience, or, what Wake, Kiker and Hildebrand (1988, p. 184) called *"learning by doing"*. This 'learning from experience' or 'learning by doing' behaviour implied that these innovative farmers used Bayesian rules (described in Chapter 3) in the adjustment of their expectations regarding the technology outcomes. Marra, Pannell and Ghadim (2003) argued that, in doing so, farmers are able to reduce the uncertainty associated with their decisions. This study supports this claim as several farmers argued this was the reason for their trials.

However, trials were one of the multiple ways farmers learned about technologies, especially because not all farmers trialled a technology before its wide implementation. Farmer 09, for instance, believes on-farm trials are subject to uncontrollable factors which result in biased outcomes. This and other farmers, who did not trial technologies, learned about new technologies through scientific papers, farm-related articles (non-scientific) and other types of publications such as technology promotional material (e.g., pamphlets), research reports and, to a lesser extent, books. Additionally, these farmers went to field days and agricultural shows, participated in training courses, visited research sites or other farmers, and watched agriculture-related television programmes. Increasingly, the internet is becoming more relevant as these farmers started using it to check weather forecasts and beef prices, but more recently to browse technical information. The relative importance and effectiveness of these communication channels to learning and innovativeness were not evident and further assessment is required. Nevertheless, these results have implications for the process of development and diffusion of technologies and are further discussed in this chapter.

9.2.3 Farming Orientations

The description of the 26 Brazilian innovative beef farmers (Appendix G) showed that individual farmers held a range of unique combinations of goals and values. The various combinations of goals and values resulted in four major farming orientations captured by the farmer types described in detail in Chapter 6.

There was some evidence to suggest that these four farming orientations led farmers to pursue different farming systems, as indicated by their technological profiles (Chapter 7). Some farmer types focused on production, some on environmental and others on managerial technologies according to their goals and values. For instance, production-oriented farmer types adopted more production technologies than the environmentally-driven type. This type, in turn, had the highest adoption rates of environmental technologies of all farmer types.

The role of goals and values (orienting principles) on adoption was also evident through the analysis of the decision making of individual farmers (see discussion in Section 8.3.2). The farmers' orienting principles, encompassing both goals and values, provide a framework for decision making on whether technology adoption is suitable and desirable. For instance, in the cattle supplementation decision (Figures 8.1 and 8.2) the goal of running a natural beef system (i.e., criterion 2) was an orienting principle for farmers undertaking the first stage of the model: those with such a goal went towards exclusive grazing systems whereas those with other goals proceeded 'down' the main path. Likewise, the goals of increasing the productivity of the land or of cattle (criterion 9 and 10 respectively) were orientations for farmers going down the second stage of the tree model (Figure 8.2). Farmers with these goals went towards cattle supplementation, unless there was a constraint or a more appealing alternative. These findings reinforce the counter-argument of technology being inherently good and suitable to everyone, as discussed in Section 9.2.1. Brodt *et al.* (2006, pp. 102-103) argue that farmers are not homogeneous in their goals or in their strategies and therefore non-adoption occurs in response to this diversity rather than because solely of 'barriers to adoption'.

These findings support other research results that advocated farmers hold multiple objectives and act in accordance with orienting principles. Morris, Loveridge and Fairweather (1995), for instance, found sheep and dairy farmers in New Zealand assessed innovations from different angles given the difference in their orienting principles: sheep farmers were oriented towards increasing profitability and controlling risk, while dairy farmers focused on increasing production, efficiency and monitoring for control. They shifted their technological profile accordingly. Not surprisingly, Beedell and Rehman (2000) showed farmers who were interested in nature conservation consistently scored higher in conservation-related indices than other farmers. This interest also triggered their involvement in agri-environmental programmes. They concluded that these farmers were more open to adoption of conservation technology than other farmers. Likewise, in this study of Brazilian beef farmers, those with a conservation orientation (i.e., the CE) tended to adopt more environmental technologies than other types of farmers.

A comparison between this study and other research on farmers' farming orientations (or management styles) reveals some common features across studies, despite the great diversity of farmers' characteristics, farming systems and bio-physical aspects. For example, Fairweather and Keating (1994), based on farmers' goals, found three major management styles among a variety of pastoralists and crop producers in New Zealand: the Dedicated Producer, the Environmentalist and the Flexible Strategist. Brodt *et al.* (2006) also described three management styles among almond and wine grape producers in California, United States: the Production Maximiser, the Environmental Steward and the Networking Entrepreneur. These farmer types resemble the four farmer types identified among Brazilian innovative beef farmers, as shown below (Table 9.1). Farmer types in the same row had similar farming orientations (or management styles).

Table 9.1 Farmer types described in three studies on farmers' goals and values

Farmer types in this study	Fairweather and Keating (1994)	Brodt *et al.* (2006)
Professional Farmer	Dedicated Producer	Production Maximiser
Committed Environmentalist	Environmentalist	Environmental Steward
Aspirant Top Farmer	Flexible Strategist	Networking Entrepreneur
Profit Maximiser	-	-

The management styles identified by Fairweather and Keating (1994) and Brodt *et al.* (2006) bear many similarities to three of the four farming orientations (or management styles) found in this study. The Dedicated Producer and the Production Maximiser, like the Professional Farmer, ran the farm as business and, as such, emphasised sound financial control and high yields and quality, accepting the environmental consequences of farming. They also found most joy in farming and, generally, were not interested in off-farm pursuits. These farmer types seem to value farming intrinsically, which means, according to Gasson (1973, p. 527), that farming is *"valued as an activity in its own right"*.

The Environmentalist and the Environmental Steward, similarly to the Committed Environmentalist, tried to manage their farms in cooperation with nature as they placed high value on environmental stewardship. Conserving natural resources had higher priority than getting high productivity and production for these farmers. They were also business-oriented, i.e., they wanted to keep farming, like other farmer types. Their business orientation, however, differed from others as they were willing to sacrifice some current income for the sake of being more environmentally friendly and having a sustainable farm system. Like the previous farming orientation, these farmers seemed to have an intrinsic orientation to farming: they had a preference for being in a natural and healthy environment, and being independent.

The Flexible Strategist and the Networking Entrepreneur, in turn, resemble the Aspirant Top Farmer in their emphasis on marketing and external orientation. In general, these farmers had a strong interest in off-farm activities, including the opportunities for social interaction with their peers and other experts. Similar to foregoing descriptions of the Aspirant Top Farmer (Chapter 6), the Networking Entrepreneur also used the knowledge acquired externally to improve the farm management by becoming more business-minded and entrepreneurial. Given this business-minded characteristic, the Networking Entrepreneur, like the Aspirant Top Farmer, emphasised the analysis of costs. For these related farmer types, it appears that both the social and the expressive orientations described by Gasson (1973) fit. It seems that farming was seen as a means of self-expression (e.g., meeting a challenge and feeling pride of ownership) while providing opportunities for social interaction, which were both valued by these farmer types.

The identification of a fourth farming orientation in this study, i.e., the Profit Maximiser, was novel and extended the set of orienting principles that have been found in previous Q-studies. Apart from two goals in common with the Flexible Strategist (i.e., reduce the workload and improve the quality of life), the Profit Maximiser did not resemble any particular farming orientation previously identified. The Profit Maximiser's prevailing goal was to have the maximum profit feasible, which suggests this type of farmer prominently held what Gasson (1973, p. 527) described as an instrumental orientation: farming was *"viewed as a means of obtaining income and security"*. This farmer type emphasised making the maximum income and safeguarding income for retirement (as described in Chapter 6), which was in sharp contrast with Fairweather and Keating's (1994) findings that none of their farmer types perceived profitability as an end in itself. Likewise, farmers in Brodt *et al.*'s (2006) study viewed profitability as a mean to ensure the farm longevity rather than as an end-goal in itself. The Profit Maximiser (PM) type found in this study also differs from the profit maximiser farmer, defended by neo-classical economists, in that the PM brings some clarity on other goals and values held by this farmer type.

As the findings indicate, farmers in different countries, or in different industries, may have similar farming orientations. However, the way they developed, and the reasons for, these orientations may be different. For instance, Brodt *et al.* (2006) argued the views of the Environmental Stewards, which comprised mostly young farmers (less than 45 years), were likely to reflect the increasing societal concerns for environmental issues. However, this was not verified for the Committed Environmentalist, whose farmers were on average 61 years old and had started farming 30 years earlier, when a production focused approach to farming was considered *"good farming"*. Thus, the CE's choice of pursuing a different path than the majority of farmers seems to be related to these farmers' personality as well as their family influence, as reported by farmer 2 (Chapter 6).

The farming orientations reported here are not exhaustive as other farming orientations may be additionally identified. Nevertheless, the fact that they have been consistently reported across studies suggests these farming orientations should be further investigated by scholars and considered by policy makers. Additionally, the proportion of each farming orientation (or farmer type) in the population is required to the development of sound agricultural policies.

9.2.4 The social milieu

Results showed that farmers' 'web of influencers' comprised several social actors. These included other farmers, researchers, extension professionals, private consultants, input salesperson and family members. The relative importance of these social actors varied.

The 26 innovative beef farmers did not integrate immediate family into farming. Some extended family, including parents and siblings, were more commonly involved in the business structure than wives and children. In general, women and children lived in town and had a cosmopolitan lifestyle, independent of the farm business. They hardly got involved in farming decisions, unless a strategic decision, with impact on the family as a whole, had to be made. Farmers, in turn, transited between the rural and the urban settings, as most of them also lived in town (77%) and some 46% had off-farm businesses too. As a result, they generally did not develop a strong sense of belonging to the rural community and most did not see farming as a lifestyle, despite being passionate about it (Appendix H). Moreover, their cosmopolitism corroborated to their business orientation to farming.

The low participation of family in farming draws attention to the atypical social organisation of the 'family businesses' of these innovative farmers. This 'family business' organisation (described above) is in sharp contrast with other livestock farms. Teixeira's (2005) study of dairy farmers in two important milk production areas in Brazil showed, for example, that all family members worked on the farms. Additionally, while the innovative farmers with off-farm work were business owners, Agrosoft (2001, as cited in Teixeira, 2005) reports that some 64% of Brazilian dairy farmers are workers in off-farm businesses to complement their income. The 'family farm' described here also contrasts with corporate farms, which usually involves a professional management with the main objective of maximising investors' returns. It appears from a holistic analysis of these innovative beef farmers that their farms incorporate elements from both the typical family farm and the corporate farm, putting them somewhere in between these types of farm structure. This has implications for the farmers' goals as illustrated by their strong agreement with the idea of running the farm as a business and, in contrast, their low sense of belonging to the rural community (Appendix H).

The characteristics mentioned above challenge what has traditionally been considered a 'farmer'. Commonly, a farmer is socially constructed as someone who lives on and from a farm, whereas several 'farmers' in this study did not live on the farm and worked on the farm occasionally, despite having beef farming as their major source of income. Given these characteristics, these innovative beef farmers can be labelled 'cosmopolitan beef farmers'. This cosmopolitan characteristic of innovative beef farmers, however, has been reported in several studies with other types of Brazilian beef farmers, which is evidence to support that this social group is well-established in the country. Pereira (2001), analysing human resources management among top beef farmers in *Minas Gerais* State, Brazil, found a high proportion of them living in town (93% of the 43 sampled) as they considered the city life more comfortable for their families and a provider of better education services compared to rural areas. Also, several farmers owned off-farm businesses, which contributed 58% of total income (against 26% in this study). Costa (1998), in a study of 100 beef farmers randomly selected in *Campo Grande* region of *Mato Grosso do Sul* State, found that 93% of the farmers lived in town and 59% had off-farm sources of income (the relative contribution of beef farming to the total income was not mentioned). Cezar (1999), also studying beef farmers in *Campo Grande* region, described a random sample of 60 farmers of which 57% had off-farm activities, contributing 55% of their total income. Likewise, studies with beef farmers in *Pará* (Corrêa et al., 2005), *Rondônia* (Melo Filho *et al.*, 2005) and *Goiás* (Pereira *et al.*, 2005a) States (reported in detail in Chapter 2) reiterated these characteristics.

This social organisation of the family farm revolving around a typical 'cosmopolitan beef farmer' is likely to indirectly impact on technology adoption through his goals. The high adoption of managerial technologies by the Aspirant Top Farmer, for example, seems to have been influenced by his external-orientation and off-farm experience, as discussed in Chapters 6 and 7. However, no definite claim can be made because no formal comparison between 'cosmopolitan' and 'non-cosmopolitan' beef farmers was carried out.

Various social actors, other than family members, seemed to be relatively more important for technological decision making; the so-called 'important others'. Their importance varied throughout the stages of the decision making process. During the awareness stage, when farmers get the first insights on a technology (Dimara & Skuras, 2003), they appeared to share and exchange ideas with their peers, experts, extended family (when applicable) and, sometimes staff. This is an indication that these social actors played a role in farmers' learning about a technology, what Conley and Udry (2001) describe as *"social learning"*. The persuasive role of influencers or a social pressure for a particular behaviour, as pointed out by Ajzen (2005), was not clear though.

During the adoption decision itself, the process was carried out solely by the farmer, as illustrated by the decision tree models (Chapter 8). Therefore, farmers' claims of being 'open' to others when making decisions (Chapter 6) seem to be limited to the awareness stage. The centralisation of decision making by Brazilian beef farmers has been also reported in other studies (Cezar, 1999; Corrêa et al., 2005; Costa, 1998; Melo Filho et al., 2005; Pereira, 2001; Pereira et al., 2005a).

After a decision was made and implemented, 'important others' were used to 'validate' the decision, particularly among the Aspirant Top Farmer. Some examples that illustrate farmers' desire for validation include the field days they carried out to get feedback from their peers and the fact that several of them asked the interviewer for an assessment of their farming systems at the end of the interviews. Furthermore, in a situation where the adoption decision was unsuccessful, experts and other farmers were of most relevance to help them to sort things out.

Being affiliated to particular groups of beef farmers (Association of Producers of Young Steers – APYS; and Good Agricultural Practices Programme – BrazilianGAP) was another important social influence on these farmers' technology adoption. A direct influence was the groups' regulations that establish farming practices farmers are encouraged, and sometimes required, to comply with. Indirectly, the adoption of particular technologies might have been socially reinforced by peers within the same social group (e.g., APYS) as these farmers mentioned they like to exchange ideas before making a final decision. The extent of the direct and indirect influences of these social groups on technology adoption and how this process occurs were beyond the scope of this research and were not further investigated.

9.2.5 The technology attributes

As discussed in Chapter 7, the five technology attributes proposed by Rogers (2003) were also found relevant for the adoption decisions of the 26 innovative beef farmers. These attributes are: compatibility, trialability, observability, relative advantage and complexity. In this study, all technologies found to have high levels of adoption have compatibility with farmers' goals and farming systems. In general, the technologies more commonly accepted were relatively less complex and less expensive to implement, and in some cases were more observable and divisible (i.e., enable trialling). Furthermore, the advantages of new technologies outweighed former technologies, otherwise farmers discontinued adoption.

In Rogers' (2003) diffusion theory, the five attributes of technologies are described, but there is no mention of any particular hierarchy among these attributes. Results from this research, however, suggest that the relative importance of each attribute is not the same. It seems that compatibility and relative advantages of technologies (including profitability) are the most important attributes determining technology adoption. Observability and trialability facilitate, but do not by themselves either determine or preclude adoption. Similarly, technology complexity does not preclude adoption, but is given consideration relative to the technology advantages. If the benefits of a technology are sufficient, then innovative farmers will adopt despite negative issues related to complexity.

Farming orientations provided farmers with a framework for decision making, as discussed in detail in Section 9.2.3. By implication, these farming orientations set the boundaries for what farmers considered compatible with their farming systems, with impact on the likelihood of adoption. Technology compatibility, therefore, appears to be a primordial attribute farmers assess, even though this assessment is often subconscious (or pre-attentive). Further evidence was found in both decision tree models (Chapter 8), as the first cut-off point for technologies was whether they fitted within farmers' values and farming systems. The importance of technology compatibility was also highlighted in Chapter 7 as a major attribute influencing the uptake of different types of technology.

Alongside compatibility, farmers assessed the relative advantages of technologies. Farmers analysed several aspects associated with a technology that altogether determined whether or not adoption was advantageous relative to a current technology or other alternative technologies. In this analysis, it seems that these farmers accepted some negative, less valued, aspects of a technology when the highly valued aspects were positive and superseded the former. These aspects included economic returns, reduced risk, implementation cost, quality improvement, rapid achievement of results, premium price, time saving and low requirement for specialised workforce. Adoption was likely among these farmers if these aspects exceeded those in the former practices, like Rogers (2003) advocated.

Complexity was another *aspect* that farmers assessed, rather than an attribute on its own, as proposed by Rogers (2003). Complexity was a deterrent to adoption but could be overcome by other highly valued aspects of technologies. While less complexity facilitated technology adoption, being complex was not by itself a sufficient condition to prevent adoption. For example, the majority of farmers implemented rotational grazing despite the complexity arising from the dynamic elements of plant growth, climatic conditions, animal intake, and the associated need for skilled staff to manage this grazing system. However, given that farmers were convinced about the technology benefits, they were prepared to pay the costs involved, as farmer 24 illustrated: *"I'm going to use it if returns are clear (...) even if it's difficult"* (F24). Complexity was, thus, another aspect analysed in the context of relative advantages of technologies.

The results above suggest that farmers' adoption decisions are more complex than a simple rule of thumb such as: 'if a technology increases returns, then I will adopt it'. In fact, decisions were made through a combination of aspects (shown in the decision trees) with farmers willing to trade-off aspects of technologies given technologies are not necessarily advantageous in all aspects. By implication, this trade-off followed farmers' prioritisation of aspects, which, in turn, was likely affected by their prevailing goals (or farming orientations). A typical example was the use of feedlot to finish cattle. Several farmers (e.g., F05 and F09) argued they were willing to accept some negative returns (or breakeven) with the use of this technology because, in the long run, it would support a shorter production cycle (i.e., a major goal), which they believed is economically viable.

Relevant, but of secondary importance to adoption, were observability and trialability prior to major commitment. Adoption of technologies was facilitated by many of them being divisible, allowing for trialling, and therefore reducing the adoption risk. Several farmers mentioned that, whenever possible, they ran experiments with a technology on a small scale before a wide implementation. The lessons learned through observing and trialling a technology allowed farmers to constantly update their constructions of it and improve their understanding of its relative advantages. This learning style was referred to as 'learning by doing' (Wake *et al.*, 1988), in Chapter 4. Additionally, several technologies and their results were observable, which also facilitated adoption by allowing farmers to 'learn by seeing'. Farmers' 'learn by seeing' style was also evidenced in their comments that they usually visited other farms and research sites before adopting a technology.

Non-observability and indivisibility of technologies, however, did not by themselves preclude adoption by individual farmers. According to Rogers (2003, p. 258), these two attributes affect farmers' ability to assess technologies, particularly during the awareness stage of decision making. While this may impact on the speed of the diffusion process, the adoption decision by an individual farmer is unlikely to be determined by any of these two attributes of technologies. The sampled innovative farmers, for example, mentioned several alternative sources where they sourced technological information, including their social network, seminars and papers among others. Given this study did not analyse farmers' level of exposure to particular technologies (i.e., stage on the learning curve) or their rates of adoption over time, no further conclusions can be drawn with this regard.

9.3 How Do Farmers Make Technology Adoption Decisions?

Results showed that farmers are unique and considered numerous criteria, comprising economic, managerial, social and bio-physical aspects, when assessing technologies. The most important criteria were included in the decision tree models (Chapter 8). The findings pointed out, and the models illustrated, that the decision on whether or not to adopt a particular technology was construed on the basis of farmers' goals and values, personal characteristics including attitudes towards risk, farming systems, available resources and constraints. Moreover, the level of understanding of each technology was underlying farmers' decision rationale. All these factors affected farmers' perceptions of the technology compatibility and applicability to their specific farming condition. If these were negatively perceived, farmers did not adopt the technology, which was rapidly eliminated.

What is more, farmers did not assess a technology on its own but in comparison to other alternatives; usually, their current technology. This comparative assessment of technologies was described in Gladwin's (1989) theory of real-life choice (reported in Chapter 3) and confirmed by Sambodo (2007, pp. 252-253). Sambodo's study showed that farmers considering the adoption of *'pandu'*, a new technology, compared it to their current farming system. In the present study, this comparison was only implied in the decision tree models (Figures 8.1 to 8.3) given the decisions were modelled as 'adopt - do not adopt' rather than 'adopt X - adopt Y'. This approach was undertaken because the research interest was on the process of decision making itself rather than on technologies 'X' or 'Y'. In 'adopt - do not adopt' models, the alternative technologies were not specified *a priori*; they were made explicit during the interviews by farmers themselves. For instance, in the cattle supplementation decision, the protein-salt complex was compared with the options of de-stocking or maintaining cattle on pasture whereas, in the cost analysis decision, these alternatives included having no cost control, controlling cash costs or operational costs instead of controlling total costs.

The models suggested that adoption occurred when the technology under consideration was generally perceived as superior to alternative technologies, if no one constraint applied; non-adoption occurred otherwise. These findings confirmed Rogers' (2003) claims that a technology should be better than the one it supersedes. However, his claim that adopters' characteristics may affect the aspects that farmers consider the most important was only implied in this study. As discussed previously, it seems that farmers trade-off negative for positive, highly valued, aspects of technologies, with the weighing of aspects likely being affected by their values and goals.

9.4 Thesis Review and Main Conclusions

One factor influencing a farm performance is the level of technology uptake. To promote the adoption of technologies and increase the farm performance, several studies have been undertaken highlighting current or potential benefits of innovations and identifying the barriers for adoption. Commonly, underlying such studies are a pro-technology bias and a view of a passive farmer, whose non-adoption is explained by a constraint that should be identified and removed. Additionally, several studies assume a farmer whose objective is to maximise profit and acts in response to economic drivers.

Alternative schools of thought acknowledge, however, that this is a simplistic view of human nature and attempt to identify the various reasons, including non-economic motivations, justifying farmers' adoption and non-adoption behaviours from their own perspective. In line with this philosophy, this research attempted to gain insights on the adoption behaviour of Brazilian innovative beef farmers using a qualitative research approach. The focus on innovative farmers was justified by their open-minded attitude towards new ideas, including innovations, and their social role in the diffusion process by making the bridge between researchers and other beef farmers.

The 26 innovative beef farmers purposively sampled were self-selected in terms of innovativeness as they voluntarily joined innovative programmes for beef production in *Mato Grosso do Sul* state, Brazil: the Association of Producers of Young Steers (APYS) and the Good Agricultural Practices Programme (BrazilianGAP). Eight additional innovative farmers were also sourced from APYS, and were used to refine the decision tree models, presented in Chapter 8.

Using a multi-method approach that combined the Q-methodology, the Ethnographic Decision Tree Modelling, to a lesser extent the Personal Construct Theory, and elements of Grounded Theory alongside descriptive statistics, the three research questions were addressed and the research objectives reached. A description of how these were achieved is presented below.

Research question 1: Is there diversity of major goals and values amongst Brazilian innovative beef farmers, and if so, how can this diversity be characterised?

This research question was mainly addressed by carrying out the analysis of the innovative beef farmers' goals and values using their sorting of 49 statements (Q-sorts) on business, family and lifestyle-related topics (Chapter 6). Through the mapping, comparison and contrast of their goals (research objective 1), it was possible to both demonstrate that these innovative beef farmers had diverse goals and values, and to characterise them by grouping and labelling farmers according to the similarities in their prevailing views, namely: the Professional Farmer, the Committed Environmentalist, the Profit Maximiser and the Aspirant Top Farmer. The farmers' discourse was also incorporated in the analysis, refining the interpretation of farmer types and their viewpoints.

Research question 2: How does diversity within innovative beef farmers' goals and values affect adoption and non-adoption of technologies?

This research question was considered in Chapter 7, where the farmers' technological profiles (i.e., adoption rates), as a whole and for different types of technologies, were presented. Initially, the technologies that have been adopted (or not) by these innovative farmers were identified from a list of 45 technologies (research objective 2). Aggregate adoption of the three categories of technology (production, environmental and managerial) by the four farmer types was evaluated, throwing light in their relationship, if there was any (research objective 3). Analysis of specific technologies uptake was also undertaken to identify other factors determining these farmers' adoption behaviour.

These innovative beef farmers tended to adopt more of the technologies that were highly compatible with their values and farming systems. It seems that farmers' values and goals were working as major drivers for their decision making, determining whether a technology was compatible or suitable to their farming systems, as the decision tree models later demonstrated (Chapter 8). It appears, though, that the farmers' values and goals are a necessary but an insufficient condition to determine adoption, as other factors are also influential to the actual behaviour (e.g., capacity to adopt).

Research question 3: Do innovative beef farmers use a different set of constructs when assessing different types of technologies? If so, why?

In Chapter 8, the achievement of research objectives 4 (model decisions on one production and one managerial technology) and 5 (compare constructs used by innovative beef farmers that justify adoption and non-adoption of these two contrasting technologies) provided the answers to research question 3. Farmers generally used economic, managerial, and bio-physical criteria when deciding about technologies. By modelling two contrasting technologies, it was clear that these innovative beef farmers construed them differently. Factors contributing to such constructions were the type (production or managerial) and the nature (‘hard’ or ‘soft’) of the technologies as well as the farmers’ level of understanding of each of them. Thus, decision criteria, and constructs thereof, associated with a ‘hard’ production technology tended to be physical and production/profit related. Decision criteria (and constructs) associated with a ‘soft’ managerial technology were predominantly conceptual and related to the farm management, but dissociated to production and profit aspects. These differences in constructs between the two technologies, however, seemed to concentrate on the second stage of the decision making (DM) process, comprising the motivational criteria for adoption. This result suggests that the elimination-by-aspect (first stage of DM) was somewhat similar for the technologies, indicating that, irrespective of their type and nature, they both were initially assessed in terms of compatibility and constraints to adoption.

Research objective 6 (describe the main factors influencing decision making on technology uptake or rejection) was achieved by the conjoint analysis of the findings in Chapters 6 to 8 alongside the discussions undertaken in this chapter (Chapter 9). Results showed that farmers’ goals and values provide the framework for technological decision making, including economic and non-economic motivations. The farmers’ attitude to risk seemed to underlie the decisions as risk taker farmers adopted relatively more technologies than risk neutral or risk averter farmers. Other factors also played a relevant role in the actual behaviour. These included the farmers’ education and their level of understanding of particular technologies, the technologies attributes and the social milieu. Within the social milieu, the particular case of the farmers’ cosmopolitism was emphasised as a potential influence on these farmers’ adoption behaviour. The lack of participation of family in farming led these farmers to pursue a management style that was mainly business-oriented and, to some extent, detached from the family’s goals.

All the findings from this research taken holistically provided evidence of how and why Brazilian innovative beef farmers make decisions on the adoption of technologies (the overall research goal). Four main conclusions were drawn and are presented below.

1. **Adoption and non-adoption are both rational decisions.**

Innovative farmers in the present study did not adopt all technologies, but strategically selected those that conformed to their personal values, goals, farming systems and level of knowledge. Besides being compatible, the relative advantages of technologies were also relevant attributes determining adoption. It was suggested that adopted technologies were generally perceived by farmers as superior to other alternatives, even though some negative, less valued, aspects were present. This indicated that individual farmers prioritised different aspects of technologies. It seems such a prioritisation was influenced by their preferences and prevailing goals, which in turn, determined whether or not a technology was suitable and feasible.

Consequently, a lack of compatibility, unsuitability of a technology or a constraint (i.e., infeasibility) were all factors explaining the non-adoption behaviour. The decision tree models provided empirical evidence for this claim and demonstrated that farmers deciding not to adopt a technology went through a complex and thoughtful decision making process, similar to adopters. This means that the non-adoption behaviour is as rational as the adoption behaviour given the farmers' level of understanding of each technology. Therefore, non-adoption is not necessarily a failure of extension services or a result of barriers that should be removed.

Whether these farmers' adoption decisions were the most suitable (i.e., optimal) for their condition is beyond the scope of the analysis undertaken in this research since the aim was to gain insights on technology adoption and decision making from an 'emic' perspective (as opposed to an 'etic' perspective) rather than making recommendations to optimise the beef system.

2. **Innovativeness is not a synonym of adoption.**

It follows from conclusion one that being innovative includes both adoption and non-adoption behaviours. Although it is acknowledged that a high adoption of technologies indicates a high degree of innovativeness (i.e., openness to new ideas), having more modest adoption rates does not necessarily mean a low degree of innovativeness. As previously discussed, these modest adoption rates may be due to lack of compatibility or unsuitability of technologies, or constraints to adoption, rather than farmers' lack of interest in adopting new technologies. Moreover, it was suggested that innovativeness goes beyond adoption and includes the creation of new technologies by farmers themselves and the adaptation of research-based innovations to local farming conditions.

Therefore, an argument can be mounted that the farmers' innovativeness is a combination of their creativity, adaptive skills, openness to new ideas and the resulting adoption/non-adoption behaviour. The latter refer to their ability to strategically select and successfully implement suitable innovations from a pool of technologies available. By implication, an innovator or an innovative farmer is not necessarily an adopter of technologies, which is a simplistic label for farmers. While this label has been useful in case studies on the uptake of particular technologies, it provides a poor description of farmers' overall approach to technology adoption and their complex and unique processes of decision.

3. **Adopters and non-adopters of a particular technology construe it differently.**

The ethnographic decision trees showed that adopters of a technology went through different paths to the non-adopters, reaching, therefore, different outcomes. This is an indication that farmers who decided to adopt a technology used different criteria relative to those who opted not to adopt it. By implication, adopters and non-adopters had diverse views (or constructions) on particular technologies, which explained their actual behaviour.

4. **The construction of a particular technology within adopters may also vary (the same applies to non-adopters).**

The diverse constructions of a technology were not limited to adopters and non-adopters, but included the diverse views within each of these groups too. As the decision trees demonstrated, adopters of a technology did so for various reasons. For example, some farmers decided to supplement cattle with protein-salt complex because they had a manufacturing plant and produced crops so supplementing cattle was a straightforward decision. Others, who did not have the plant, considered the return on supplementation and, as they believed it was positive, they decided to supplement cattle. Likewise, non-adopters may have reached a decision through various paths, also indicating diverse constructions of a particular technology. Using the same example of cattle supplementation, some farmers opted not to use supplementation because it was incompatible with their values and farming systems or because they were constrained, while others because they believed other alternatives were more suitable to their farms. Farmers pursuing the same path and reaching the same outcome, however, construed technologies similarly.

9.5 Theoretical Contributions and Implications

The findings from the present study provide significant contributions to theory and practice with relevant implications to both. The combination of methods for data collection and analysis allowed the understanding of different aspects of the (non-)adoption decision providing a more holistic assessment of farmers than if only one method was used. One theoretical contribution was the expansion of the definition of the innovation process, which, according to this study, goes beyond the adoption of technologies. Rejecting the idea that innovation is adoption solely means that new ways of approaching farmers' innovativeness are required and the inclusion of new elements need to be considered, such as non-adoption, the farmers' creativity, informal knowledge and adaptive skills. This has impacts on the adoption research, which must respond accordingly through the development of, or application of existing, methods to account for these issues. This is even more important for the studies on 'soft' technologies, which have an 'ethereal' character by nature, and need to be properly defined and approached.

This study also contributes significantly to a wider body of literature on 'farmer types', farming orientations and management styles (Beaudeau, van der Ploeg, Boileau, Seegers, & Noordhuizen, 1996; Brodt *et al.*, 2006; Fairweather & Keating, 1994; Gasson, 1973). In particular, the identification of a fourth farmer type (i.e., Profit Maximiser) expanded the current knowledge of major farming orientations, indicating that some innovative farmers are heavily driven by economic goals. It is acknowledged that these farmer types are not exhaustive as other types may be also identified. However, the recurrence of some of them across different studies under diverse contexts suggests that there may be some consistent goals throughout the entire population of farmers, which should be further investigated.

The description of a 'cosmopolitan beef farmer', who lives in town with his family, has a off-farm business and visits the farm occasionally, reinforces similar results of studies involving Brazilian beef farmers, suggesting this a well-established social group. From a theoretical point of view, this challenges what has been commonly considered a 'farmer' and a 'family farm', enhancing the overall understanding of farmers' social contexts. This seems to have somewhat influenced these farmers' technology adoption and has implications for researchers and extension practitioners, as discussed in subsequent sections.

Also of relevance was the finding that the five attributes of technologies proposed by Rogers (2003) seem to be actually four, with complexity being one aspect considered alongside other relative advantages. More importantly, these attributes appear to have a hierarchy of importance with compatibility and relative advantages being the most important. Of second importance are observability and trialability, which facilitate farmers' assessment of technologies, but whose absence does not preclude adoption.

9.5.1 Decision making models

The present study provides a significant contribution to decision making theories, in general, and in particular to ethnographic decision tree modelling (EDTM). Building on existing studies using EDTM, an original contribution was the modelling of a decision on a 'soft' technology and its comparison with a contrasting technology (as opposed to sequential decisions). While most adoption studies using EDTM have focused on 'hard' technologies, particularly of the production or the environmental types, the modelling of a 'soft' technology that was of the managerial type showed decision criteria were predominantly conceptual, comprising the farmers' goals, knowledge about, and perceptions of, this technology. More importantly, the comparison of this model with the decision tree on a 'hard' technology further enhanced the understanding of the farmers' decision making by: (1) highlighting the lack of production and profit-related criteria for the soft technology; (2) providing evidence to support the claim that farmers were more knowledgeable on the production rather than on the managerial technology; and (3) suggesting that the initial assessment of technologies, irrespective of their type and nature, is similar, but farmers' overall constructions of 'hard' and 'soft' technologies are different, particularly with regards to motivations to adoption (second stage of decision making). These are original contributions that have not been reported previously. An implication is that researchers studying the farmers' decision making process must account for the type and nature of the technology (ies) being modelled so that the theories on how these factors influence on the selection of particular decision criteria become more robust.

9.5.2 Technology adoption theories

This study reinforces the theory that farmers have multiple, and often conflicting, goals, including economic and non-economic ones (Fairweather & Keating, 1994; Gasson, 1973; Wallace & Moss, 2002), as shown in Chapter 6. This is in contrast with the neo-classical view of a farmer as a profit maximiser acting in a world of full certainty. Moreover, results suggest that the farmers' prevailing goals provide a framework for decision making on technology adoption. It is acknowledged, though, that these goals change over time, as suggested by the different average age among the farmer types. The decision models, therefore, are a snapshot of the paths farmers took under a given set of goals.

The realisation that farmers' goals operate as major drivers for decision making has been reported in the literature. What is novel is the association of sets of goals and actual adoption behaviour, as presented in Chapter 7, since other studies have solely focused on the description of these goals (or farmer types). The farmer types (representing particular sets of goals) tended to adopt technologies that were consistent with their values, goals and farming systems. Possibly, having a particular set of goals acts upon farmers' intention to adopt a technology, which, according to Ajzen (2005, p.117), is the most important immediate determinant of the adoption behaviour.

However, holding a particular set of goals and values did not fully explain these farmers adoption behaviour as they mentioned several other influential factors to adoption (Chapters 7 and 8). For instance, farmers with the aim of increasing cattle turnover tended towards supplementation, but may have not adopted it because of a constraint. This was referred to by Hurley and Hult (1998) as 'capacity to adopt'. Other influential factors to adoption were illustrated in the decision trees (Figures 8.1 to 8.3). An implication of these findings is that, while the understanding of the farmers' values and goals is necessary for providing the context upon which decisions are made, it proved to be an insufficient condition to fully understand the adoption behaviour. In contrast, the decision trees provided a more complete 'picture' of farmers' thinking proving to be more insightful when it comes to their actual behaviour.

Another contribution was the finding that both adopters and non-adopters of a technology make rational and thoughtful decisions given their level of understanding of it. The implication of this is that farmers are not passive recipients of technologies and non-adoption is not only a result of constraints. This result indicates that effective interactions with farmers need to be participatory in order to gain further insights on their non-adoption behaviour. It shows that rather than aiming at the removal of barriers to adoption, theorists should look at other facets of non-adoption and understand it within a wider context of the farming system.

Likewise, adoption was motivated by diverse factors which mean that adopters of a technology had different reasons for pursuing their behaviours. For technology adoption theories, this translates as a need for identifying specific motivations for adoption in order to well-target the promotion of technologies among the diverse farmer types that exist.

9.6 Practical Contributions and Implications

Stakeholders potentially benefiting from the results of this research include farmers, researchers, extension practitioners and policy-makers. Farmers indirectly benefit from the results of this study as the knowledge generated by this study can be used to improve research and extension services as well as support the development of sound agricultural policies. The implications of the findings to other stakeholders, in contrast, are direct and are hence explored below.

9.6.1 Agricultural research and extension (AR&E)

There are two stances of implications of the findings to agricultural research and extension: (1) implications for AR&E in general; and (2) implications of the case studies on specific technologies.

In general, the decision models showed that farmers construed a ‘hard’ and a ‘soft’ technology differently. The immediate implication of this finding is that these differences must be accounted for by researchers and extension practitioners if they want to increase the chances of adoption. While ‘hard’ technologies are tangible, the conceptual and non-observable character of ‘soft’ technologies requires a special way of developing, communicating and disseminating such technologies, irrespective of being production, environmental or managerial related. This includes methods that facilitate the farmers’ learning of the technology ‘properties’ and its potential benefits. Some examples include the incorporation of a ‘soft’ into a related ‘hard’ technology (e.g., software to control beef production costs), the use of concrete farming examples that farmers relate with to explore the concepts encompassing the technology and the creation of opportunities for farmers to experiment with, and discuss about, the ‘soft’ technologies.

The way in which technologies are developed, communicated and disseminated must also account for the farmers’ diverse learning styles, including their social learning, explored in detail in the Section 9.2.2. The fact that most farmers made adoption decisions on their own and did not involve family in these decisions means that research and extension must primarily focus on beef farmers rather than their family members. Some consideration may also be given to their cosmopolitan lifestyle since it may have impacts on farmers’ preferences for time-saving and easy-to-use technologies, given they visited the farms only occasionally (although this preference was not tested in this study). The farmers’ interactions with other farmers, researchers and rural consultants suggests these were ‘important others’. They played a role mainly in the awareness stage of decision making as well as in the validation of decisions. An implication is that the farmers’ network provides opportunities for the dissemination of technological information. Actions that stimulate the exchange of ideas and experiences between farmers and ‘important others’ seem to be relevant and therefore, must be encouraged.

Besides the importance of social learning for these farmers, their specific learning styles also have implications to AR&E. Using the classification of the learning styles proposed by Wake *et al.* (1988), it was shown that these farmers had prevailing observational and experiential learning styles rather than the informational style. The former two are associated with learning by seeing and by doing respectively, while the latter relates to learning by reading and writing. This means that, in terms of technology diffusion, practices that facilitate the farmers' observation of, or experimentation with, technologies are likely to be more effective than printed material about the technology. Some examples of these practices include field days, visits on research sites and training courses with practical classes. Farmers often mentioned television programmes on agricultural issues, and increasingly, the internet as sources of technological information, suggesting both may additionally become key types of media in the near future.

All the above issues point to the direction of more participative approaches to agricultural research and extension so that farmers' demands can be appropriately assessed, their local knowledge and aspirations can be incorporated in the research models, which, in turn, may be able to address more effectively these farmers' needs. Furthermore, the use of participative research approaches should also allow for the identification and quantification of the diverse sub-groups of beef farmers in the major population. This will create greater market segmentation of technologies, enabling well-targeted actions to attend specific demands of the various groups of beef farmers. As a consequence, beef farmers would no longer be taken as a homogeneous group with similar objectives and for whom technology applies indiscriminately. Rather, the several sub-groups that make up the beef farming sector should be acknowledged, considering their diverse values, objectives, farming systems, resources, constraints and demands.

Although the objective of this study was not to increase adoption of particular technologies, an assessment of the diverse types of technologies does have some practical implications to AR&E, as well as to policy-makers (discussed subsequently). For example, results in Chapter 7 indicated that environmental technologies highly used by these innovative farmers were more compatible with production systems. This means that environmental technologies that simultaneously support beef production are likely to be more easily accepted by these farmers and should therefore be emphasised in research programmes. In contrast, environmental technologies perceived as detrimental to production (e.g., set aside land for conservation) may need the support of policy-makers to facilitate adoption. This support may be in a form of external incentives, including, among other options, subsidised credit for the implementation of such technologies, the payment of carbon credit and technical assistance to farmers.

Regarding production and managerial technologies, the implications revolve around the farmers' better understanding of the bio-physical issues than they do have of costing principles. Therefore, attempts to increase the uptake of cost analysis by farmers must focus on the impacts of using costing principles on the farm performance, particularly in terms of beef production and profit. Nevertheless, the fact that several farmers with no, or basic cost control, have been able to keep farming and improve their farms without external funds raises issues on the need for sophisticated cost analysis. They had other complementary tools (e.g., budgets) to support their financial management, which seemed to somewhat cover the lack of advanced cost control. Further research is needed to better understand farmers' financial management and the contribution of the diverse financial and economic analyses to the farm's financial health.

9.6.2 Policy-making

As suggested throughout this study, education was an underlying factor for decision making and technology adoption since it was shown that innovative beef farmers were mostly well educated. By implication, their high adoption rates may be associated with their years of schooling. For policy-making, this means that institutional efforts must continue to ensure that the Brazilian population, including rural populations, have access to good quality education. Moreover, government support is needed through their agencies and institutions for continuous training programmes for farmers. Particular emphasis must be given to increasing their economic literacy as the decision models suggested they were less knowledgeable on a managerial than on a production technology.

Furthermore, training programmes should not be restricted to farmers, but include all levels of personnel. Given these farmers' occasional visits to the farms, operational staff and foremen are crucial to the adoption of new technologies, as several farmers pointed out during their interviews (Chapter 6). Foremen, who are usually in charge of supervising other workers and handling technologies in the field, need to be constantly trained. Operational workers also need training to handle technologies adequately. The quality of workforce was a strong constraint to several technologies reported by farmers, and should be appropriately addressed by policy-makers.

Another aspect of this research that has implications to policy-makers is the types of innovative beef farmers identified here. Similar to suggestions for AR&E with this regard, policy makers must account for the diversity among innovative farmers if they want to effectively develop and implement sound policies. Only by acknowledging the various types of beef farmers, their proportion within the population and their needs and aspirations, will policy-makers be able to address specific agricultural issues of well-targeted groups of farmers. For example, the promotion of environmental technologies among farmer types, other than the Committed Environmentalist (CE), may require additional efforts from policy makers given they were less willing to uptake this type of technology. In this case, policy makers need to know the proportion of the farmer' types in the population to estimate, among other things, the costs of an environmental scheme targeting these production-oriented farmers, and the best way to approach them.

9.7 Limitations of the Findings

The main overall limitation of this study refers to the generalisation of the findings since the small sample size and sampling method exert some limit on the extrapolation of results to the wider population of farmers. While this would be a serious pitfall for research aiming at the prediction of farmers' adoption behaviour, the prevailing exploratory nature of the present study and its aim of expanding the current understanding of technology adoption among innovative beef farmers make this limitation less important. Hence, the objective is to generalise the findings to theories, following the premises proposed by Yin (2009, pp. 14-15). Nonetheless, all steps were taken to ensure rigorous analysis of empirical data, including a triangulation of methods, so that internal validation was achieved.

Other limitations relate to the research methods used here. In the study of these innovative farmers' goals and values using Q-methodology, it was observed that some farmers had too many statements they agreed with and were encouraged to move these around until the Q-sort diagram was fully filled. This 'forced-free' manipulation of statements within pre-defined categories (i.e., a +/- 4 scale) may have introduced a bias as farmers had to find aspects to downgrade statements. However, farmers tended to move statements they did not have strong feelings about (i.e., close to the neutral position) and this bias was minimised. According to McKeown and Thomas (1988, p. 34), this bias is *"more apparent than real"* as the subjects are free to move statements around and, in doing so, they determine themselves the meaning of the continuum.

Some results from Q-methodology also have limitations related to the factor loadings. This was the case of the two farmers' loading significantly on factor two, who formed the Committed Environmentalist type. Although this factor proved to be important in the context of farmers' farming orientations, the small number of farmers loading on this factor decreased its reliability. For example, one farmer had one of the highest adoption rates of all farmers while the other farmer had the lowest adoption rate of all 26 farmers. This made the factor interpretation more challenging and vulnerable to misinterpretation. Another example of limitation related to farmers' loadings was the presence of six multiple loaders that loaded significantly on two or more factors. Despite having their views somewhat represented by these factors, they did not contribute to the study of goals (Chapter 6) or the analysis of goals as determinants of the adoption behaviour (Chapter 7).

Regarding the decision tree models, some limitations are also observed. The decision trees drawn in the present research are snapshots of decisions. While they provide useful insights on recent decisions made by farmers, extrapolation of decision criteria for future decisions may not be appropriate since this study suggested that farmers' goals change over time and so do decision criteria. Moreover, as farmers become more knowledgeable about technologies, other criteria may become relevant to them. Perhaps, in stable farming systems the decision trees are also more stable and may be extrapolated, with caution, to a near future. A consequence of the static character of these models is the lack of dynamic aspects of decisions. These were mostly introduced in the models as 'unless conditions' and also reported in auxiliary tables for the supplementation decision (Tables 8.2 and 8.3).

Finally, adoption decisions were modelled dichotomously resulting in deterministic outcomes (i.e., 'adopt' or 'not adopt'). Consequently, the findings are inconclusive to the intensity of adoption, that is, to which extent the technology has been adopted by farmers. In the cattle supplementation case, adoption was the outcome if a farmer declared to use protein-salt complex, irrespective of the number of animals receiving it.

9.8 Suggestions for Future Research

Suggestions for future research include both further investigations of the findings of this study and research on technology adoption issues that were not approached by this research. In the former case, studies should be carried out to identify other beef farmer types and to determine the proportion of each type within the population. This has implications for AR&E and policy making, as discussed previously. Moreover, further investigation of the farmers' goals and values as determinants of adoption is required to make this association clearer as the findings here were only suggestive.

Additionally, the hierarchy of technology attributes suggested in this study should be tested against empirical data to provide a better understanding of the relative importance of them in the context of adoption.

Within the themes that have not been explored in depth in this research and that deserve further consideration are: the modelling of decision making on an environmental technology;

the comparison of decision models on production, managerial and environmental technologies all of which are of a 'hard' nature or, alternatively, comparisons among 'soft' technologies only (of the three types, for example); and, sequential decision making, incorporating the dynamics elements of this process and their interconnectedness.

9.9 Concluding Remarks

The present case study of Brazilian innovative beef farmers showed that technological decisions are complex and involve multiple criteria, including economic, technical, biological, managerial and social aspects. Nonetheless, it also demonstrates that farmers have rational reasons to do what they do. In general, all the participant farmers have a common goal which is to achieve steers that are finished at young ages. This, *per se*, is innovative in the Brazilian context and physical environment. However, they choose different technologies, through adoption and non adoption, to achieve this. Their choices depend both on their goals and values, and on the physical and financial bundle of resources that they have at their disposal. It is the resources, goals and values that determine the farming system. This, in turn, influences how these farmers perceive the technology attributes, particularly compatibility, and hence defines adoption and non adoption of specific technologies.

These findings suggest that to understand farmers' multifaceted decision making (DM) holistic approaches, such as Soft System Thinking (SST) (Checkland,1999), seem to be more appropriate than reductionist methods. The analysis of specific aspects of DM provide fragmented views on farmers' actual cognitive processes and motivations for particular behaviours, and overlooks the integrated nature of all the aspects. The application of SST, in contrast, permits a better understanding of the whole by holistically considering the linkages and relationships among its components. Is also accommodates the multidisciplinary nature of agricultural decisions. More importantly, SST aim is to structure and improve the problem-situation rather than to problem-solving. In this context, research is undertaken to gain insights on farmers' technological decisions, learn from them and organise the debate to improve the development of new technologies. This approach empowers farmers, putting them at the focal point of research, which is developed with farmers rather than to farmers (i.e., normative research).

In practical terms, this means that participatory research with a 'farmer-centric' approach is needed if a higher technology uptake and innovation among farmers is expected. In other words, rather than a top-down or linear approach to the transfer of technologies (TOT), it is necessary to involve farmers throughout the entire process and understand their diverse motivations. It must be acknowledged that farmers' needs and perceptions may be different from researchers' expectations and this gap must be reduced. These propositions are in line with the ideas of participatory research proposed by the 'farmers first' movement and its subsequent theoretical expansions such as 'farmers first revisited' (Scoones & Thompson, 2009).

Although the technology transfer model (TOT) has played a relevant role as an inductor of change in the agricultural sector, by itself it seems insufficient to promote further change considering the complexities involved in technological decisions. What is more, TOT is based on a questionable premise that technology is inherently good and, therefore, should be widely adopted. This research provided evidence that it is not and its usefulness is determined by the technology users (farmers) rather than developers (researchers). So the question to be answered is "for whom a particular technology is suitable and desirable?".

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Appendix A

Preliminary list of statements for the Q-sort

A comprehensive list of 133 statements is presented below. Relevant statements for this study are in bold and were used as basis for the formulation of the final 49 statements used in the Q-sort (see Appendix H for the final statements). In Table A.1, codes B, F and LS assigned to the statements stand for business, family and lifestyle respectively. The sources of these statements are also presented in Table A.1, as follows: (1) Cezar (1999); (2) Wallace and Moss (2002); (3) Costa and Rehman (1999); (4) Ohlmer *et al*. (1998); (5) Gasson (1973); and, (6) Fairweather and Keating. (1990). Methodological aspects relative to the selection of particular statements were discussed in Chapter 5.

A. 1 List of statements on farmers' objectives, goals and values sourced from the literature

Nb.	Statement	Type	Topic	Source
1	**Belong to rural community**	LS	Status	(1)
2	**Guarantee land ownership/Maintain land ownership**	B	Risk control	(1)
3	**Increase standard of family living**	LS	Balance	(1)
4	Create opportunity of work for children	F	Succession	(1)
5	**Leave the business for the next generation**	F	Succession	(1)
6	Run the business without risk	B	Risk control	(1)
7	**Be recognised as a top farmer**	LS	Status	(1)
8	Increase profits	B	Core Business	(1)
9	Run the business without loan	B	Risk control	(1)
10	**Expand the business**	B	Development	(1)
11	Spend more time on the farm	LS	Balance	(1)
12	Transfer knowledge for the children	F	Intergenerational	(1)
13	Spend more time with the family	LS	Balance	(1)
14	**Have a herd of high quality**	B	Core Business	(1)
15	Keep the pastures clean	B	Core Business	(1)

Nb.	Statement	Type	Topic	Source
16	Be recognised by the quality of the buildings	B	Core Business	(1)
17	Be recognised by nature conservation	LS	Aesthetic	(1)
18	**Achieve the maximum profit feasible**	B	Core Business	(2)
19	Maintain or increase the family consumption level	LS	Balance	(2)
20	Growth in net worth	B	Development	(2)
21	Maintain sufficient investment to offset rate of depreciation on fixed capital	B	Core Business	(2)
22	**Restrict borrowings in a low percentage of the value of assets**	B	Risk control	(2)
23	Work in the countryside	LS	Country living	(3)
24	Maintain the social status as rancher	LS	Status	(3)
25	Pass on inheritance and way of living to next generation	F	Succession	(3)
26	**Be recognized as a progressive farmer**	LS	Status	(3)
27	**Benefit from the security and liquidity of cattle ownership**	B	Core Business	(3)
28	**Improve the family and personal standard of living**	LS	Balance	(3)
29	Keep and rear animals	B	Core Business	(3)
30	**Be your own boss**	B	Independence	(3)
31	Maximise the asset value of the cattle	B	Core Business	(3)
32	**Maximise the economic returns**	B	Core Business	(3)
33	**To have a higher private withdrawal**	B	Financial security	(4)
34	**Have social contacts**	LS	Social Network*	(4)
35	Earn living from the farm	B	Financial security	(4)
36	Have holidays	LS	Balance	(4)
37	**Keep and improve the farm**	B	Development	(4)
38	Have a reasonable amount of own work	B	Easy care farm	(4)
39	Live at the farm	LS	Country living	(4)
40	Be a farmer	LS	Identity	(4)
41	**Utilize the farm resources at maximum**	B	Core Business	(4)
42	Avoid risk	B	Risk control	(4)
43	**Develop the farm**	B	Development	(4)
44	Reduce taxes payment	B	Core Business	(4)
45	**Reduce the work load**	B	Easy care farm	(4)

Nb.	Statement	Type	Topic	Source
46	**Invest without borrowing money**	B	Risk control	(4)
47	Keep the farm in family	F	Succession	(4)
48	**Increase crops yield**	B	Core Business	(4)
49	To have a farm on my own	B	Independence	(4)
50	Decrease the debts	B	Risk control	(4)
51	To decide by yourself what to do	B	Independence	(4)
52	**Work with nature**	LS	Aesthetic	(4)
53	**Have liquidity enough not to be worried about paying the bills**	B	Financial security	(4)
54	**Be your own boss**	B	Independence	(4)
55	To do the work you like	LS	Balance	(5)
56	Be independent	B	Independence	(5)
57	To lead a healthy, open-air life	LS	Country living	(5)
58	**To meet challenges**	LS	Challenge	(5)
59	To have opportunity to be creative	LS	Challenge	(5)
60	To develop self-respect for doing a worthwhile job	LS	Identity	(5)
61	**To make a reasonable living in the present**	B	Financial security	(5)
62	**To expand the business**	B	Development	(5)
63	To make sure of income for the future	B	Financial security	(5)
64	**To make as high an income as possible**	B	Core Business	(5)
65	To have job security	B	Independence	(5)
66	To be able to arrange my own hours of work	B	Independence	(5)
67	To work close to home and family	F	Intergenerational	(5)
68	**To follow the family tradition**	F	Intergenerational	(5)
69	To belong to the farming community	LS	Status	(5)
70	To earn respect of workers	LS	Status	(5)
71	**My goal is to have an easy care farm that runs itself**	B	Easy care	(6)
72	**My goal is to reduce my workload and improve my quality of life**	B	Easy care	(6)
73	**I have taken steps to control the marketing of my produce because I want to insure I receive the best possible return from my produce**	B	Marketing	(6)

Nb.	Statement	Type	Topic	Source
74	**Farmers do not have a lot of control over input and output prices, so I will try as hard as I can to work with the situation**	B	Marketing	(6)
75	It is important to have as much control as possible over the marketing of my produce	B	Marketing	(6)
76	**To enjoy the freedom of being self-employed**	B	Independence	(6)
77	**A farmer must try to maintain control over farm work. I try to run my farm with minimal outside help**	B	Independence	(6)
78	As a farmer, I try to minimise my dependence on other businesses	B	Independence	(6)
79	**An important goal to me is to have enough money for a comfortable retirement**	B	Financial security	(6)
80	**Severely cutting back on personal expenses to keep the farm going is just not worth it - we want to live comfortably**	B	Financial security	(6)
81	Freehold ownership of land is an important goal	B	Financial security	(6)
82	**I will take a risk if the potential benefit to the farm is there – there are times when I will take a chance in order to do well**	B	Risk control	(6)
83	**My farming business is good the way it is – the secret is to avoid taking any risk**	B	Risk control	(6)
84	**A good farm manager has control over his farm and is not at the mercy of outside forces**	B	Risk control	(6)
85	**My goal is to hand over the farm in better condition than when I got it**	B	Development	(6)
86	It is important to me to keep developing my farm	B	Development	(6)
87	**I'm satisfied with the present level of development of my farm and do not intend to develop it further**	B	Development	(6)
88	Increasing production on my existing farm area is an important goal	B	Development	(6)
89	It is important to me to increase the size of my farm operation	B	Development	(6)
90	**To have little or no debt**	B	Debt	(6)
91	My goal is to have few debts, and to have my land mortgage free	B	Debt	(6)
92	**To maximise profit per hectare**	B	Core Business	(6)
93	**To run the farm as a business, with clear goals, and close attention to my cash flow**	B	Core Business	(6)
94	**My goal is to run an efficient farm through sound planning and financial management**	B	Core Business	(6)
95	**My goal is to improve farm income by decreasing production costs and responding to changing economic conditions**	B	Core Business	(6)

Nb.	Statement	Type	Topic	Source
96	**I farm to make money**	B	Core Business	(6)
97	**My goal is to diversify my assets by having off-farm investments**	B	Core Business	(6)
98	**My goal is to have the best quality livestock or plants – good husbandry is key to success**	B	Core Business	(6)
99	**Efficient and properly execution of farm work is the most significant part of running the farm**	B	Core Business	(6)
100	Cooperation among family members is an important ingredient of farm success: it is important to build good working relationships.	F	Intergenerational	(6)
101	**We want to keep the farm in the family and to pass it on to the next generation**	F	Succession	(6)
102	**To give the children the opportunity to go farming if they want to**	F	Succession	(6)
103	To be free of parents influence and run the farm the way I want	F	Independence	(6)
104	Education or travel is not really all that important when it comes to running our farm. Our children know they always have a place on the farm	F	Goals for children	(6)
105	To educate our children at a good school	F	Goals for children	(6)
106	**To encourage our children to go away for education or travel and then let them decide if they want to go farming**	F	Goals for children	(6)
107	To encourage our children to seek alternatives to farming	F	Goals for children	(6)
108	**My goal is to share farm work and farm decisions with my spouse/husband**	F	Role Men/Women	(6)
109	Farming today still is really a man’s job: women help but the responsibilities fall on a man’s shoulders	F	Role Men/Women	(6)
110	It is important to have something to fall back on if you can’t continue to farm	LS	Outside interests	(6)
111	It is important to spend time with my family	LS	Outside interests	(6)
112	**To keep and maintain interests outside the farm**	LS	Outside interests	(6)
113	Balancing farm and household needs is a constant and difficult aspect of farming	LS	Balance/Lifestyle	(6)
114	**A lot of people put too much emphasis on the business end of farming: it is a lifestyle as much as a business**	LS	Balance/Lifestyle	(6)
115	**Business goals must take priority over household needs**	LS	Balance/Lifestyle	(6)
116	**It is important to me to live life now: you shouldn’t let your farm rule your life**	LS	Balance/Lifestyle	(6)
117	Farming can give job satisfaction like no other	LS	Balance/Lifestyle	(6)
118	**One virtue of farming is that you can have your family working alongside you**	LS	Balance/Lifestyle	(6)

Nb.	Statement	Type	Topic	Source
119	**To work with animals**	LS	Balance/Lifestyle	(6)
120	To raise my children in the country	LS	Country living	(6)
121	**To live the outdoor life close to nature**	LS	Country living	(6)
122	Establish your identity by being a farmer	LS	Status	(6)
123	**It is important to me to be recognised as a good farmer in my community**	LS	Status	(6)
124	To be close to children and grandchildren	LS	Later life	(6)
125	**To maintain some involvement in the farm, even after retirement, and keep active and fit**	LS	Later life	(6)
126	**To be challenged and stimulated and to avoid boredom**	LS	Purpose/Challenge	(6)
127	To feel like I'm contributing to the farm and achieving something	LS	Purpose/Challenge	(6)
128	**To be the best farmer I can be**	LS	Purpose/Challenge	(6)
129	**To have a beautiful farm**	LS	Modesty/Aesthetic/ Conservation	(6)
130	**Nature conservation is important to me, and I rank it alongside my income goals**	LS	Modesty/Aesthetic/ Conservation	(6)
131	**The good farmer keeps things in perspective – moderate yields, modest improvements and old equipment suit me fine**	LS	Modesty/Aesthetic/ Conservation	(6)
132	**If you are successful, why not have a nice house and new equipment?**	LS	Modesty/Aesthetic/ Conservation	(6)
133	**I am very concerned about the environment and I am doing what I can to improve the situation on my farm**	LS	Modesty/Aesthetic/ Conservation	(6)

Appendix B
APYS and BrazilianGAP as sources of innovative farmers

B. 1 Association of Producers of Young Steers (APYS)

In 1998, the Association of Producers of Young Steers (APYS) was created in *Mato Grosso do Sul* State (ASPNP, n.d.). It was an initiative of pioneer beef farmers with a vision of strengthening the beef supply chain through coordinated actions amongst its members. With this purpose, APYS established strategic alliances with slaughterhouses and retailers, facilitating the flow of information on consumers' demands back to producers.

Under these market alliances, farmers are eligible for premium prices, especially for young heifers, if they meet particular requirements. The aspects required by markets include the age at slaughter, the cattle weight (minimum liveweight of 225 kg for steers and 180 kg for heifers), the fat coverage of the carcass (minimum of 3 mm), among others.

Additionally, farmers are required to put in place good farming practices, respecting the environmental legislation, using animal welfare principles, controlling the sanitary and nutritional condition of the herd, paying attention to the infra-structure and carrying out sound managerial systems. They are also required to observe work conditions and strictly follow the employment legislation. However, APYS does not require the use of specific technologies, apart from a traceability system which is compulsory to enrolled farmers. The compulsory character of traceability applies only to herds under the market alliance, which means that other cattle categories may not be traced. In general, APYS establishes general guidelines for farmers producing young cattle as the following recommendation illustrates: "use of adequate soil conservation practices". More information on APYS can be obtained on http://www.novilhoms.com.br/ (available in Portuguese only).

B. 2 Good Agricultural Practices Programme (BrazilianGAP)

The Good Agricultural Practices Programme was launched in *Mato Grosso do Sul* State in 2005 by the Brazilian Agricultural Research Corporation – EMBRAPA. The objective of BrazilianGAP is to foster food safety and sustainable production systems among beef farmers, with positive impacts on the farms profitability and competitiveness (EMBRAPA, n.d.). For this reason, several practices encouraged by BrazilianGAP have to do with government regulations around producing food safely.

Farmers' enrolment in BrazilianGAP is voluntary, but once they are enrolled they are required to meet a number of standards spanning the farm administration, human resources management, environmental practices, farm infra-structure, animal welfare, the technical issues related to pasture, cattle nutrition, reproduction, sanitary control and animal identification. These standards are divided in three categories: compulsory (C), highly recommended (HR) and recommended (R). Examples of these categories are: workers must be formally employed (C), farmers should carry soil conservation practices (HR); and, analyse costs of production (R)**.**

The full implementation of the BrazilianGAP protocol requires farmers to achieve 100% of the compulsory standards (usually related to laws and legislation), 80% of the highly recommended and 20% of the recommended. The complete list of recommendations comprises 164 practices, some of which are non-applicable in particular situations. After full implementation, farmers are eligible to receive a credential issued by EMBRAPA. This credential facilitates the process of farm certification by other external bodies while giving the enrolled farmers the opportunity to market their produce differently (EMBRAPA, n.d.).

Some of the 45 technologies selected in this research overlap with the technologies and practices recommended and highly recommended by the BrazilianGAP. However, in practice, the implementation of the standards on farms was still very limited in 2008, when the interviews were undertaken. The BrazilianGAP report showed (under the "Results" section on http://bpa.cnpgc.embrapa.br) that in August 2011 only four farms implemented the protocols and one was waiting for inspection. It is acknowledged, therefore, that despite farmers' willingness to comply with the BrazilianGAP of recommendations and uptake particular technologies, the influence of this initiative on these farmers' actual adoption was unlikely to be major.

An institutional video provides further information on the BrazilianGAP and is available on http://bpa.cnpgc.embrapa.br/images/stories/video2010/videoingles.html.

Appendix C

Descriptions of the 45 selected technologies

C. 1 Description of the 25 selected production technologies

Production technologies	Description[1]
Artificial insemination	This is a technique where cows/heifers are artificially inseminated rather than naturally mated with bulls. The selection of the bull is usually based on particular genetic traits the farmer wants his herd to improve.
Genetic Improved Bulls	This technology involves the use of tested top genetic bulls to promote rapid improvement of commercial herds.
Cross-breeding	It is the mating between two or more cattle breeds as an attempt to explore the resulting hybrid vigor in the progeny.
Embryo transfer	Through hormone stimulation, a donor cow (high genetic merit) has multiple ovulations and, when inseminated with high profile bulls, provides several embryos that are later transferred to recipient cows (low genetic merit).This technique allows for rapid genetic improvement of the herd.
Breeding season	The mating occurs within a short period of the year (e.g., from November to January) in order to have the calving season concentrated from August to October, when the incidence of diseases is low and the quality of pastures is better.
Bull fertility test	This is a test to verify semen motility, sperm cells morphology, among others to ensure bulls' fertility and high pregnancy rates.
Pregnancy test	Pregnancy testing is one method of monitoring reproductive efficiency and detecting any problems early in the breeding cycle.
Care of newborn calves	This practice involves three steps: assisting cows during the delivery, if necessary; ensuring the colostrum intake by calves; and, disinfection of the navel area and umbilical cord.
Creep feeding	It is a strategy commonly used in intensive beef systems to wean heavy calves. It consists of supplying supplemental feed (usually concentrates) to the nursing calf within a type of physical barrier (creep feeder), which prevents cows from accessing the supplement.
Early weaning	In this method, calves are weaned between 3 and 4 months of age (in contrast with the conventional weaning of 7-8 months) to induce the cows' oestrus cycle.
Castration	The removal of steers' testicles is twofold: (1) to comply with market requirements; and (2) to facilitate the deposition of fat in the carcass so that they are finished at young ages.
Cattle supplementation	Cattle are supplemented with sources of protein and/or energy, either all year round or during specific seasons as strategies to avoid weight loss or to allow weight gains.
Feedlot for finishing cattle	Cattle are confined, usually for 90-210 days, to gain weight (and particularly build a fat layer on the carcass) through high protein-energy supplementation levels. This technology differs from the feedlot as a production system because it is used strategically for a short period of time while in production systems entirely based on confinement cattle remain in the feedlot until finished.
Certified pasture seed	The certification of seed quality provides farmers with information for better decision making and ensures higher yields.

Table C.1 (continued)

Production technologies	**Description**
Pasture maintenance	It comprises weed control techniques and fertilisation to maintain pasture productivity.
Pasture recovery	There are several alternatives for recovering degraded pastures as simple as stocking rate adjustment and pasture fertilisation or as complex as crop-pasture rotation, legumes introduction, and substitution of grass species.
Pasture diversification	This practice consists of combining different grass species so that areas with different soil conditions can be explored more efficiently and at various intensification levels. It prevents disease outbreaks and spread of weeds.
Silage and/or hay	These are techniques to conserve forage for periods of pasture shortage.
Grass and legumes mix	This technology consists of sowing legumes and grass seeds simultaneously so that the legume's nitrogen fixation capacity supplants the requirement for artificial nitrogen fertilisation. The nitrogen provided by the legume improves the grass protein level.
Capineira	This is a grassy buffer area (increasingly with sugarcane) let to grow during the rainy season to harvest in the dry season.
Deferred grazing	In deferred grazing, some paddocks are reserved for consumption only during the dry season, usually supplemented with a protein source. The difference between this technology and the use of *capineira* is that there is no grazing in the latter as grass is harvested and supplied in feeders.
Rotational grazing	It is a pasture management technique that involves alternate grazing of paddocks. This system allows cattle to constantly graze high quality forage while grazed paddocks 'rest' and recover.
Strategic control of worms	This is a strategy to reduce worm infestation and to avoid the increase of worms' resistance to prescriptions. The treatment consists of providing cattle with the adequate dosage mainly during the dry season (possibly with a repetition in the rainy season), making the control technically and economically more efficient.
Culling on reproductive performance	The culling of cows occurs according to the following criteria: age (maximum age of 10 years), history of infertility or abortion, low maternal ability (to wean healthy and heavy calves), and non-pregnant cows/heifers at the end of the breeding season.
Soil testing	This technology comprises sampling soil from various areas in the farm to determine the levels of macro and micro-minerals, and sometimes organic matter, in order to efficiently recommend fertilization.

[1] Based on: Corrêa (1996), Euclides Filho, Corrêa and Euclides (2002) and Gillespie *et al.* (2007).

C. 2 Description of the 9 selected environmental technologies

Environmental technologies	**Description**[1]
Expanded protection of headspring	Consists of preserving large areas of vegetation around headsprings to protect them and preserve water quality.
Private reserve of the natural patrimony (PRNP)	This is an established reserve that has perpetual character and can only hold low environmental impact activities that must be approved by the competent government agencies. Farmers opting to create a PRNP are entitled to land tax deduction and government support to protect this area in case of environmental risk caused by fishermen, hunters or any other third parties.
Agricultural terrace	The use of this technique reduces soil erosion and surface runoff in hilly or sloped areas.
Other soil conservation practices	These comprise any additional technology to avoid soil erosion, beside the agricultural terrace. An example is the use of legumes on the terrace with grass being sowed in between terraces.
Water management and facilities	This is a watering system (trough or tank) installed to provide drinking water for animals and to eliminate cattle access to water bodies.
Manure management	Instead of disposing manure, it is used for soil fertilisation, and biogas production among others.
Heavy-use area protection	This involves the installation of suitable surface materials and the construction of structures where animals congregate (e.g., around feeders), stabilizing these areas and avoiding soil compaction.
Tree planting	The planting of trees for fencing, cattle feeding (e.g., legume tree), fruit production, shadow and/or to recover riparian forest buffer or areas of permanent protection established by law.
Fire **not** used to manage pasture	Fire is forbidden by the Brazilian Environmental Law, although several farmers still use it. Researchers claim it compromises the soils long term production capacity and causes air pollution. There are several alternatives available to farmers to manage pasture, although they are not described here. In this study, the non-adoption of fire is considered positive to the environment.

[1] Based on: Euclides Filho *et al*. (2002) and Gillespie *et al.* (2007).

C. 3 Description of the 11 selected managerial technologies

Managerial technologies	Description[1]
Animal identification	Animals are individually identified to enable performance measurement and the implementation of traceability systems. It is compulsory for animals whose meat is exported. The identification methods include hot iron marks, ear tag or electronic chips (transponders). This technology was considered 'adopted' if farmers used at least one of these methods.
Technical records	It is the record keeping of individual and aggregate performance of cattle, paddocks, other on-farm activities and the whole farm performance. It may also include records of soil conditions and fertilisation schemes, machinery maintenance, building renovation, labour productivity and others. The usual methods involve the use of cards, books or spreadsheets (in computerized systems).
Formal investment planning	By formally planning investments, farmers can predict some potential limitations of intended activities; identify the requirements for capital and labour; and estimate possible outcomes and economic returns. It can be done manually (with pen, paper and a calculator) or through specific software.
Financial control	This allows for the analysis of the capital position of the business, including the analysis of solvency, liquidity and equity.
Managerial software	It is used to control (or plan) the technical, financial and economic areas of the farm, altogether or individually.
Scale to weigh cattle	This equipment enables the measurement of cattle performance. It can be integrated with automated systems in herds implanted with transponders (individual electronic chips for identification), with weighs being automatically registered for individual animals on a specific piece of software
Sanitary control	Several sanitary practices are undertaken by farmers such as disease control, vaccination and prophylactic practices. Sanitary control consists of keeping records of which activities were carried out, when, which animals were treated and the dosage used.
Staff evaluation/reward	This is a system to measure and analyse staff performance, and to establish rewards for outstanding performance.
Futures trading	It is a trading alternative where farmers buy future contracts (in Sao Paulo Futures Market), establishing the cattle selling price in advance. This technology helps farmers to deal with price risks.
Participant on market alliance	This consists of farmers' participation in commercial alliances involving other players of the beef supply chain such as slaughterhouses, retailers and butchers among others.
Analysis of total production costs	This analysis comprises all cash costs and non-cash costs. The latter involves depreciation costs, opportunity costs (OpC) of the family labour (if it is unpaid work) and other opportunity costs (including OpC on land).

[1] Based on: Corrêa (1996), Corrêa *et al*. (2002) and Kay and Edwards (1999).

Appendix D

Model of the invitation letter to farmers

Embrapa
Gado de Corte

Campo Grande, [Date]

Dear [farmer's name],

My name is Mariana Pereira and I am a researcher from EMBRAPA Beef Cattle. I am doing a PhD in Farm Management at Lincoln University, New Zealand, and my research targets innovative beef farmers in *Mato Grosso do Sul* State, Brazil. The objective of my study is to better understand farmers' decision making regarding adoption and non-adoption of innovations. Many studies on farmers' technology adoption have been carried out based on the impact of factors such as policies, diffusion programmes and others. However, few studies have focused on farmers themselves: their objectives, perceptions, beliefs, and reasons for adoption/non-adoption of innovations. Moreover, there is no study to date with Brazilian innovative beef farmers, who play an essential role in the diffusion of innovations and, hence, in the industry development.

To fill in this gap, I am contacting innovative farmers, like you, to participate in a face-to-face interview. This study requires a deep enquiry and may take up to half of your day. I acknowledge that this is a lot of time, but the interview will be carried out in a relaxed and iterative way and I am sure you will find it engaging. The outcomes will help research institutions, such as EMBRAPA (Brazilian Agricultural Research Corporation), to develop and transfer sound technologies to the beef industry. The results may also be used for comparison in future studies.

I would be very grateful if you could assist me in my research, which has been sponsored by EMBRAPA. I will soon be in touch with you by telephone to ask if you would like to participate and, if so, to make arrangements for the interview. If you have any queries please feel free to phone me (67-3368-2193 or 67-8162-9384) or write an e-mail (mariana@cnpgc. embrapa.br). For further information about my qualifications, you can check www.cnpgc. embrapa.br/~mariana. You may also contact my advisor, Dr. Fernando Paim, at EMBRAPA Beef Cattle for complementary information about my research project. His contact details are: telephone (67) 3368-2187; fax (67) 3368-2150; e-mail: paim@cnpgc. embrapa.br

Yours sincerely,

Mariana de Aragão Pereira - Lincoln University/EMBRAPA Beef Cattle

Supervisors: Keith Woodford (woodfork@lincoln.ac.nz), Peter Nuthall, John Fairweather

Appendix E
The interview guide

The following guide was not exhaustive and was used during the semi-structured interviews to provide an overall inquiry framework. Apart from the introduction, the order of the themes presented below was not always followed to allow for farmers to speak more freely. At the end of each interview, all the themes were checked to ensure they had been covered.

Respondent number: ______________________	Location: _______________________

1. Introduction

1.1. Introduction of the researcher and the research, explaining the research objectives; and

1.2. Ethical considerations: confidentiality, the right to withdraw from the research or not to answer particular questions, consent form (agreement to participate and to have the interview recorded);

2. Background and farming systems

2.1 Farm history: was the farm bought, inherited or leased? Has the farm been always a beef cattle farm? What were the main changes on the farm since you have started farming?

2.2 Farmer's characteristics: age, education, farming experience, marital status, number of children, family life cycle, family members involved with farming, off-farm activity (percentage of total income), and income from beef farming.

2.3 Farm resources: area (total, with pasture and crops), herd structure, water availability, and available infra-structure (buildings and machinery).

2.4 Production systems: grazing system, grass and legumes species, feedlot, cattle breeds, commercial versus breeding herds, diversification with other agricultural activities, reproductive and sanitary practices, and traceability among others.

2.5 Farm management: staff (number, role and hierarchy), credit access and use, information support systems (for planning/control? which data?), marketing (input suppliers, meat buyers, future contracts, own brand, value supply chain?), sources of information, participation in farmers' groups, associations, extension programmes and other organizations, and support from consultants.

2.6 Farm performance: technical performance (AU/ha; kg liveweight/ha; calving rate; weaning rate; death rate; age at first calving and at slaughter)and economic performance (operational margins per ha, per AU, per kg liveweight; return on assets; and costs of production).

2.7 Technology profile: discuss the 45 selected production, environmental and managerial technologies (presented in Appendix C) with farmers. Consider scores 1 for adoption and zero for non-adoption.

3. Farmers' goals and values

Present farmers with the 49 statements on business, lifestyle and family issues and ask them to sort the statements according with their level of agreement/disagreement. Continue with the sorting by asking farmers' for explanations of the most agreed/disagreed statements. Check responses against information previously obtained to ensure internal validity.

4. Ethnographic interview

During this part of the interview, the farmer is asked about technology adoption in general and his specific adoption decisions on dry season supplementation for rearing cattle and the analysis of production costs. Inquiries of the ethnographic interview include:

4.1 General inquiries: When you learn about a technology, which aspects do you consider to make a decision on whether or not to adopt it? Why? Who do you discuss with before making the decision? Are you usually the first to adopt or do you wait for others to learn with them?

4.2 Specific inquiries: Where did you learn about the technology 'X'? Who did you talk to when you were considering adopting 'X'? What were your perceptions about the potential benefits and constraints before adoption? Were they confirmed? What about the risk and uncertainties related to this technology? Why did you decide to adopt 'X'? What was the previous technology that 'X' replaced? Why was it replaced by 'X'? When you adopted this technology, did you modify it somehow or just followed research recommendation? Why? Which alternative practice/technology could you implement instead? Why have you not? Why have you used this technology in one situation but not in others? Is 'z' the most important aspect for your decision to adopt 'X'? How does 'z' differ from 'y'? Are they related? Are there any aspects that would make you change your adoption decision? If so, which aspects are these?

5. Drive on the farm to identify and discuss about technologies in use (or not)

6. Closing the interview

6.1 Ask farmers to make any additional comment they want to, including his opinion about this interview.

6.2 Check the interview guide to make sure all relevant topics were covered.

6.3 Thank farmers for their participation and give them one publication from EMBRAPA Beef Cattle as sign of gratitude.

Appendix F

Example of a Q-sort and associated raw scores

Respondent number: _______________
Date: ______/______/______
Starting time: ____________
Finishing time: ___________

				1				
				25				
			30	45	16			
			11	38	28			
			47	31	48			
		15	5	41	3	22		
		46	19	37	12	35		
		23	34	21	43	4		
	20	2	49	13	8	9	32	
	10	40	27	14	36	42	17	
18	26	33	44	6	29	39	24	7

Raw Scores

-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**

Appendix G

Descriptions of the farm and the farmers

G. 1 Aggregate results for innovative beef farmers, as a whole and per factor

FARMERS' CHARACTERISTICS	*FT 01*	*FT 02*	*FT 03*	*FT 04*	*ML*	*Total*
Number of farmers in each group	9	2	4	5	6	26
Average age (years)	60	61	52	44	50	53
Farming experience (years)	25	30	17	11	19	20
Live on the farm (%)	33	-	-	-	50	23
Married (%)	100	100	75	80	83	88
Retired (%)	56	-	50	20	17	35
Tertiary education or higher (%)	68	50	75	80	83	73
Average number of children	2.7	3.0	2.2	1.8	1.3	2.1
Have off-farm activities (%)	22	50	50	80	50	46
Income from farming (%)	93	100	58	72	52	74
FARM DESCRIPTION	***FT 01***	***FT 02***	***FT 03***	***FT 04***	***ML***	***Total***
Average farm size (hectares)	2,983	1,465	5,428	2,507	1,784	2,874
Minimum farm size (hectares)	487	1,430	162	250	600	162
Maximum farm size (hectares)	10,000	1,500	19,200	5,207	3,300	19,200
Average pasture area (hectares)	1,758	910	3,137	1,521	1,313	1,749
Average crop area (hectares)	315	350	20	480	12	468
Average herd (head)	2,697	900	4,240	2,146	2,050	2,541
Average number of employees	7.3	3.0	6.7	5.2	6.5	6.3
Beef Production System (%)						
Cow/Calf	11	-	-	20	-	8
Fattening	11	-	-	-	-	4
Rearing + Fattening	11	50	25	40	17	23
Complete	67	50	75	40	83	65
On-farm diversification (%)						
Commercial agriculture	56	-	-	20	-	23
Sheep	44	-	25	40	-	27
Dairy	22	-	25	20	-	15
Stud (Breeding herd)	22	-	25	20	50	23
Others*	11	100	25	20	17	-

*Others comprise: swine, horses, fish, sugarcane, horticulture, forestry and ecotourism.

G. 2 Descriptions of individual Brazilian innovative beef farmers (cases)

In this appendix, each of the 26 innovative farmers is briefly described. Farmers are presented within the farmer types identified in Chapter 6 to facilitate the perception of common emerging patterns. Initially, farmers in factor one (Professional Farmer) are described, followed by those in factors two (Committed Environmentalist), three (Profit Maximiser) and four (Aspirant Top Farmer). Finally, multiple loaders are presented along with the multiple factors they loaded into.

For each case, the farmer's background and family history are reported, followed by a description of the production system and the farm overall management, often including the sources of farming information. Subsequently, the adoption rates of production, environmental and managerial technologies (farmers' technological profile) are reported for each farmer alongside their accounts for particular adoption behaviour. Adoption rates of specific technology per individual farmer were presented in Appendix I. Some selected photos that illustrate these farmers' beef systems and, in particular, the technologies they used are included throughout this Appendix.

Factor 1 – The Professional Farmer

Farmer 05

Background

Farmer 05 is 51 years old, married and has two sons. This farmer, with a bachelor in business administration, took the farm over in 1984. His brother, a 41-year-old married agronomist, joined him in 1992. The brothers discuss all prospective decisions and claim they have been working in great harmony, although farmer 05's opinion clearly prevails. They make their living out of farming and live on the farm. Their families live in the city, because of school.

History

Farmer 05 and his brother had no experience in farming prior to the farm purchase in 1972. The farm was cleared and beef cattle were established, as *per* the environmental laws[20]. Production and productivity have been improved by means of technology adoption, particularly related to pasture management, genetic improvement and sanitary control. Consequently, age at slaughter has dropped from 48 to 28 months.

Farming system

This farm is 5,509 ha, of which 3,926 ha is pasture. Farmer 05 has both commercial and purebred breeding herd, totalling 6,000 head. He engaged on a genetic management programme to make qualified decisions on breeding schemes and uses heat synchronisation and artificial insemination on purebred cows. Top genetic calves remain in creep-feeding. Within the commercial herd, farmer 05 runs a complete cycle system, under which cows are usually mated with high genetic merit bulls during a mating season of four months. Grazing systems prevail with few categories being supplemented during the dry season. Ten percent of calves (218 head) are sold at weaning, with the remaining being fed with a protein-salt complex[21] during the first dry season and confined in the second dry season. Heifers have no

[20] By law, farms in the *Cerrado* ecosystem must keep at least 20% of its area as 'Legal Reserve'. Also, water bodies, headsprings and hills must have surrounding vegetation, the so-called 'Permanent Preserved Areas' (PPA).

[21] 30% Mineral mix, 10% Urea, 15% Corn meal; 45% consisted of soybean meal and cotton meal.

supplementation and graze until finished. Annually, farmer 05 sells 218 purebred cattle and around 920 finished animals at 24 to 28 months.

Farm management

Farmer 05's main aim is to improve production efficiency to be able to increase cattle turnover. Given the low qualification of the workforce and the barrier this represents, he established a policy of personnel development. Another strategy is the use of a traceability system as a managerial tool and the record keeping of numerous technical data.

Beside the technical control, he controls the finance, recording sales and expenditure which provide him with monthly reports on his cash flow. His awareness on the farm financial situation has allowed him to borrow money 'responsibly', usually limited to less than five percent of his total capital. Other factors also limited his borrowings including the paperwork, the long time to process the application and the low credit limit.

Farmer 05's investment strategy seeks to keep fixed costs low and infra-structure tight and functional. His willingness for investment is influenced by his perception on beef and other markets.

Technological profile

Overall technology adoption rate: 82%
Production technology adoption rate: 88%
Environmental technology adoption rate: 78%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

This farmer had the highest average technology adoption of all interviewed farmers with high levels of adoption across all technology types (production, environmental and managerial). This is consistent with his aim of increasing his farm efficiency. **Efficiency** is critical to farmer 05 as he wants to make the most of the available resources, including infra-structure, which is kept as simple and functional as possible. **Functionality** expands to technology in general. Farmer 05, for instance, shifted the cattle identification method from ear tattoo to ear tag because he found the latter more efficient to read and record information as well as easier to apply.

Future market price is a criterion that also influences farmer 05's decisions as he monitors the external environment and scans for market opportunities. He decided, for instance, to mate and sell pregnant cows instead of finishing them when he predicted there would be a shortage of breeding cows in the market.

Before adoption of technology on a large scale this farmer likes to **test technology** a few times to learn from it and adapt it to his conditions, when necessary.

The main factors that prevented him from, or led him to discontinue, technology adoption are the availability of **machinery** and **infra-structure** required by technology as well as **staff limitations** (i.e., number of employees or their qualifications). For example, he cannot supplement the entire herd during the dry season because he would need additional feeders, warehouse (e.g., to store supplement), staff and tractors to distribute supplement.

Farmer 05's brother is a major influence on his adoption and non-adoption behaviour. Farmer 05 claims they work very well together because both acknowledge the younger has expertise, as he is an agronomist, and the older (farmer 05) has experience. Other farmers also trigger their adoption behaviour as farmer 05 quite often interacts with his peers.

Farmer 07

Background

Farmer 07 is 73 years old, retired from his professional job, married and has three adult children. Farmer 07's daughter has a degree in business administration and works at the farm office in town, helping with paperwork and controls. Farmer 07 lives in town and has five farms nearby that he visits almost every day.

This farmer has only primary education and was involved with farming from an early age as his parents were farmers in the South of Brazil. In order to learn more about farming and keep up to date with innovations, he visits EMBRAPA offices and the MS Foundation, takes training courses with SENAR and APYS and watches seminars and television programmes on cropping-related subjects.

Farming system

In total, farmer 07 owns 8,000 hectares, distributed over his five properties. Most of his land is devoted to cropping while beef cattle have been a secondary activity. Beef is produced on a 1,000 ha farm and under cattle-cropping integrated system (CCIS) on the other farms. The average herd is 1,700 head resulting in an annual beef production of 3,600 head. He also produces swine and milk; the latter was mostly for own-consumption. Clearly, diversification is very important to this farmer.

The interview occurred on his 1,000-hectare-farm, which was bought in 1986. Initially, it was covered with native pasture, which was gradually replaced by improved quality pasture after two years of cropping. He uses a rotational grazing system on 700 ha, the remainder being legal reserve, a permanent preservation area (PPA) or used by the swine production.

Farmer 07 runs a rearing-fattening production system where he buys only crossbred heifers ranging between eight and 10 months. The decision to raise heifers only is based on the premium beef price paid for heifers, their lower purchase price and better performance (they need no castration) relative to steers. Cattle are fed all year round with a protein-salt complex during the dry season and an energy-salt complex during the rainy season. Four months prior to slaughter cattle are provided with concentrate to finish appropriately and are sold with ages ranging from 24 to 26 months.

Farm management

For the traceability system, records are kept on vaccination, deworming and other basic practices. He used to have various performance indicators, but found data collection and analysis too demanding and gave this up. Since then, farmer 07's decisions are made on a more intuitive basis. When it comes to finances, however, his daughter maintains a detailed information recording practice. She organises each activity and its corresponding operational expenditure and revenue into different accounts, managing the overall cash flow.

One aim farmer 07 has for the near future is to improve his pasture through cultivation and then hand the farm over to his children.

Technological profile

Overall technology adoption rate: 47%
Production technology adoption rate: 40%
Environmental technology adoption rate: 44%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

This farmer's intermediate level of technology adoption on his beef farm is a reflection of his greater interest in cropping, which provides him with higher income. He deliberately tries to keep beef farming simple because crop production is time consuming.

As this farmer claims, he is not often a pioneer in adoption since he likes to **visit other farms** to see *"what they are doing right and what they did wrong"*. However, once he decides on adoption, he does not use small scale tests, but follows research recommendation (e.g., CCIS). Ongoing adoption, on the other hand, depends on a continuous evaluation of the **cost-benefit**: if cost goes up he tries to adapt the technology accordingly where possible, or discontinues it. Examples of these two situations are supplementation and fertilisation: when supplement ingredients price becomes more expensive, he changes the diet towards cheaper options; when fertiliser prices go up he stops fertilising pasture.

Another factor that contributes to technology discontinuation is the **time demand**. If a technology or a practice is too time consuming he is likely to discontinue its use as he has five farms to manage and cannot afford wasting time. In some extent, this is also related to the **difficulty in using** a technology, which is another limiting aspect for this farmer. The opposite is also true so this farmer considers adoption of technologies he can understand and handle easily.

One factor that stops this farmer from adoption is the **incompatibility** between his current farming system and new technologies or practices. In his view, for instance, planting trees on pasture is not feasible for two reasons: (1) trees make cropping difficult in being obstacles to machines and limit his plans to reform pasture with cultivation; (2) cattle kill single trees by scratching against them, unless they are fenced, which makes the process more expensive.

From a social standpoint, this farmer's main influence on adoption is his farm manager and other farmers. He enjoys discussing his ideas with them before implementation. Although his children work alongside him, none plays a major role on his beef-related decisions. His two sons are only consulted on crop production whereas his daughter is in charge of paperwork solely.

Farmer 08

Background

Farmer 08 is a 61-year-old retired business administrator, who is married and has three adult children (two daughters and a son). Only his son lives with him and his wife on the farm, as he graduated in Animal Science and is temporarily working there. The couple has no off-farm jobs and their income is entirely reliant on farming.

History

In 2003, this farmer's wife inherited the farm and two years later the couple took it over. Farmer 08 had almost no farming experience prior to this. He claims he has been farming for three years only and that has been an intense learning process. To support this learning process, farmer 08 constantly seeks farming information on the internet, magazines, newspaper and publications (EMBRAPA inclusive). In addition, he often goes to seminars and talks to consultants and other farmers. A result from this learning process is the evolving environment of this farmer's farm.

Farming System

The developing farming system consists of a complete cycle beef production on 530 ha, 424 ha being pasture. A herd of 962 grazes continuously on large paddocks, which, in his view, has been preventing more efficient cattle management (i.e., grouping by age). *"High stocking rate and overgrazing are inevitable"*, as farmer 08 pointed out. Breeding cows are mated with high genetic merit bulls in order to improve the herd performance and meat quality. Calves are supplemented up until weaning through a creep feeding system. After weaning, they are reared exclusively on pasture. When cattle are close to the slaughter date they are sent to the best quality pasture on the farm, where they are provided with supplements. The average age and weight at slaughter is 3 years and 450 kg liveweight, respectively. Beside cattle, farmer 08 also has fruit trees and a small sheep herd (27 head) for consumption by his family and staff families.

Farm management

In order to organise the farm business and make informed decisions, farmer 08 keeps technical and financial records. His wife is in charge of gathering and processing information (both technical and financial) using the spreadsheets they developed themselves. Cattle inventory and land use are examples of technical information they record, although no performance indicators are worked out (e.g., weight gain). As cattle are traced and the farm is enrolled in ERAS/SISBOV[22], they also have cows' pregnancy records and sanitary controls (e.g., vaccinations dates and deworming practices). When it comes to financial control, this farmer keeps records of expenditure and revenue for tax purposes and, more importantly, checks cash availability to make investment decisions. For the latter purpose, farmer 08 usually relies on consultants' support.

Although this farmer claims he enjoys farming, he does not see himself farming in ten years time. He believes beef production in the near future will no longer be viable in the region his farm is located (i.e., micro-region), since land use has been shifting towards more profitable enterprises (e.g., crop production, sugarcane etc.). However, he thinks that along with profitability comes risk and this is something he is not willing to take as he is getting older. Therefore, he will hand the farm over and let his children choose what to do.

22 ERAS/SISBOV stands for Approved Rural Establishments in the Brazilian Identification and Certification System of Bovine and Bubaline Origin (SISBOV). To be accredited by the Ministry of Agriculture, Livestock and Food Supply, farms have to comply with several requirements, including the implementation of a reliable traceability system, and undergo through periodic certification.

Technological profile

Overall technology adoption rate: 27%
Production technology adoption rate: 24%
Environmental technology adoption rate: 13%
Managerial technology adoption rate: 45%

Motivations and barriers for technology adoption

In general, farmer 08 had a low technology adoption rate. The low adoption of production and environmental practices were the main contributors to this result. To put into perspective, one needs to consider that this farmer is new in the business and has only three years of experience. Thus, the whole farming system is unstable and going through constant change while farmer 08 is learning about farming. He runs small '**experiments**' to decide whether a technology is suitable for his farm. The higher adoption of managerial technologies, on the other hand, results from his background in business administration and post-graduation in finance.

This farmer's main motivation for technology adoption is its **perceived potential benefits** (e.g., higher meat quality, higher beef production etc.). Such benefits are considered relative to the actual practices and are usually experimented on a small scale before complete adoption. Some examples are his projects on homeopathy and irrigation, that he wants to compare with prescribed deworming and a 'no-irrigation' system, respectively. Potential benefits are also analysed under the market perspective, resulting in changes in adoption depending on beef market stimulus. An example was the establishment of a traceability system, which he believes will entitle him to claim premium beef prices in the future. His enrolment at the Good Agricultural Practices Programme (BrazilianGAP) from EMBRAPA was also a response to market as farmer 08 believes in doing so he will get higher price for his produce. Being part of BrazilianGAP, on the other hand, had implications to technology adoption as the programme requires some improvements in the farm.

In contrast to the motivations for adoption are the factors that prevent this farmer from, or led him to discontinue, adoption. In the first stance, if technology is seen as **incompatible** with his actual farming system it is immediately disregarded (pre-attentive stage of decision). Reforestation, for instance, is one of the cases this farmer eliminated at a very early stage of assessment as it is recommended for poor soils whereas his farm has high fertility soils.

Risk is also a factor that prevents this farmer from adopting technology. Farmer 08's attitude towards risk is related to his life stage, he argues. Moreover, it is accentuated by his lack of farming experience. Risk is the reason he did not consider diversifying into cropping, even though he acknowledges his land is more suitable for crop production and this is more profitable than beef production.

It is also because of his perception on risk that he does not consider borrowing money an option. The implication of this to the farm management is that farmer 08 relies exclusively on his own finances. As a result, technology **implementation cost** is often a barrier for this farmer. His rule of thumb is: *"If I have cash I may adopt. If I don't have cash I won't adopt"*.

Cash availability is not only a reason for non-adoption behaviour but also for technology discontinuation. Discontinuing fertiliser due to increased prices, and hence, a higher demand on the cash flow was a typical example. Other reasons to discontinue technology are: difficulty of use, demand for qualified staff and **disappointment with results**. Once farmer 08 gets frustrated with technology results he gives up on it, particularly if he does not realise what the problem is. One example was the artificial insemination, which resulted in 34% pregnancy rate, and was replaced by natural mating.

Since this farmer's wife and son are involved with farming and make their living out of it, they are influential on his decisions. His wife is involved when important decisions have to be made (e.g., shift from beef to crop production) whereas his son's opinions are important for operational decisions (e.g., cattle handling decisions). Additionally, farmer 08 enjoys discussing his ideas with other farmers and consultants. The latter is generally hired when he wants to implement a new project (e.g., irrigation and supplementation).

Farmer 10

Background

Farmer 10 is a 65 year old agronomist who worked for a fertiliser company. He is retired and has no off-farm activities, making his living out of farming. He is divorced and remarried his current wife, who is studying farm management and is helping on the farm, particularly with managerial tasks (controls and analysis). He has two adult children, none working in agriculture. She has one son who is an agronomist but is employed on another farm.

History

This farmer had a farm in the South of Brazil where he used to crop. In 1977, he sold that farm and moved to *Mato Grosso do Sul* State. Initially, he was sowing cash crops but decided to diversify into beef cattle. Such diversification was triggered by crop market instability and this farmer's aim to mitigate such a risk. He selected beef cattle among other options because of its less volatile market. When he first started beef production, he was fattening heifers in feedlots. Later, he shifted to rotational grazing.

Farming system

Since 2000, this farmer has been using a cattle-cropping integrated system (CCIS) along with no-tillage practices on his 487.5 ha farm. This system involves 380 ha of cropping (soybean and maize), 50 ha of pasture during the rainy season and 84 ha during the dry season. Pasture is replaced with crops every year under a rotational scheme. Such a scheme allows farmer 10 to intensify production, resulting in a stocking rate of 4.5 hd/ha of pasture (or 1.4 AU/ha). The average herd consists of 300 heifers, which he usually buys at 200 kg at 15 to 18 months of age and finishes in approximately 30 months of age at 360 kg of liveweight. Farmer 10 finishes 260 head annually, which provide him with 20 percent of his total income. Although his main focus is on cropping, he believes cattle plays an important role in the whole system as it helps to improve soil conditions and prevents diseases while mitigating market risks.

Farming management

As a response to market requirements, all cattle are traced. Farmer 10 is enrolled in ERAS/SISBOV and, therefore, has to keep records such as insecticide and pesticide application and sanitary control (e.g., vaccination). He also records cattle inventory, the animals' weight and weight gain. In addition, farmer 10's wife has spreadsheets to control expenditure and cash flow. She organises expenditure and revenue by account plans (discriminate expenditure into cattle, cropping and administrative accounts) and is trying to use financial reports to support decisions. Farmer 10 admittedly has become more risk averse and wants the farm to run smoothly, with no sudden down turns. Borrowing money, for instance, is only considered for cropping and usually limited to operational costs (but not for investment).

In ten years time, farmer 10 and his wife plan to keep producing cattle on 100 ha and lease the remainder to a crop producer. They want to be more productive and control costs more efficiently. In this way, they believe they will have low risk and a comfortable retirement while keeping active and working.

Technological profile

Overall technology adoption rate: 62%
Production technology adoption rate: 60%
Environmental technology adoption rate: 50%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

Farmer 10, in general, had a moderate level of technology adoption. Although he regularly claims he wants to keep up and improve production, he is more cautious when deciding on investments in beef than in cropping, where he is more experienced. This explains his moderate uptake of production and environmental technology. In contrast, managerial technologies had a high rate of adoption. Arguably, his wife influenced this as she is completing a degree in farm management.

Farmer 10's **aversion to risk** is an outstanding criterion for technology adoption. He opted, for instance, to diversify into beef cattle production to mitigate cropping risks. He also used to produce excess silage to avoid the risk of running out of food during the dry season even though he claims he did not need it. He has been hedging crops using futures trading to ensure margins for his cropping produce. Another example is his habit of **visiting several farms** or '**running experiments**' on his farm before he actually adopts technology. He claims he is not impulsive when making decisions and does not like to be the first to adopt innovations.

He also tests, and often adapts, technology to his conditions. He constantly reassesses results to decide whether to discontinue it. One factor that motivates him to adopt is the **ease of use**. In contrast, one factor that leads him to discontinue adoption is the difficulty in handling technology. An example is silage; He considered it hard to prepare and maintain, and therefore stopped its production. He also changed grasses as he found the former one too difficult to manage under CCIS. In this case, technology was not only hard to handle but also unsuitable to his farming system. Hence, **suitability** is another aspect farmer 10 considers when assessing innovations. He discontinued a grass-legume mix, for instance, because weather conditions were unsuitable (i.e., frost).

Any **cash flow** limitation is a strong factor preventing this farmer from adoption. This is particularly important in the context of his business improvement horizon as this farmer is unlikely to borrow money to finance cattle production.

Farmer 10 is socially very active and has been a member of the rural union, APYS, exchange experience group, the MS Foundation, a cooperative and the church. He also maintains close contact with other farmers and consultants, including input sale representatives. This interaction with people and research institutes, along with his participation in several seminars, has been an important source of farming information for farmer 10, and thus supporting his decision-making process. The ultimate influence on his decisions, though, has been his wife, who gradually has been taking over several tasks farmer 10 used to carry out.

She is not only developing her managerial skills, but also is studying and learning about beef cattle production to help her husband with technical decisions.

Farmer 11

Background

Farmer 11 is 59 years old, married and has three daughters, one of whom has an interest in farming although not in agriculture. He finished primary school and later did some technical training in agriculture. He has 36 years of experience in farming, which is his only source of income. Crop production makes up 75 percent of his total income whereas the remainder comes from beef production.

History

As a European descendant, born in Southern Brazil, he was raised in a rural community where it was common to develop several on-farm activities simultaneously such as poultry, hogs, dairy and cash crop. This cultural setting proved to be a major influence on how he pursued farming in his later life. Farmer 11 bought his first piece of land (96 ha) in 1976 and kept buying land until he reached 995 ha, the current size of his property. Initially, he used conventional cultivation but later started no-tillage cropping and crop rotation. Because of his cultural background, he always dreamed of having cattle along with cropping. His first experience with beef production was limited to finishing cattle during the dry season. From this, he expanded to a complete cycle system established in a fixed area adjacent to crops fields. In 1989, this system evolved as he decided to alternate cattle and crops throughout the rainy and dry seasons under a rotational system (cattle-cropping integrated system – CCIS). This system remains on his farm to the present.

Farming system

The CCIS is established on 800 ha, subdivided in four 200-hectare paddocks, with one paddock being sowed with pasture and three with various cash crops during the rainy season. This proportion inverts in the dry season (see Figure G.1).

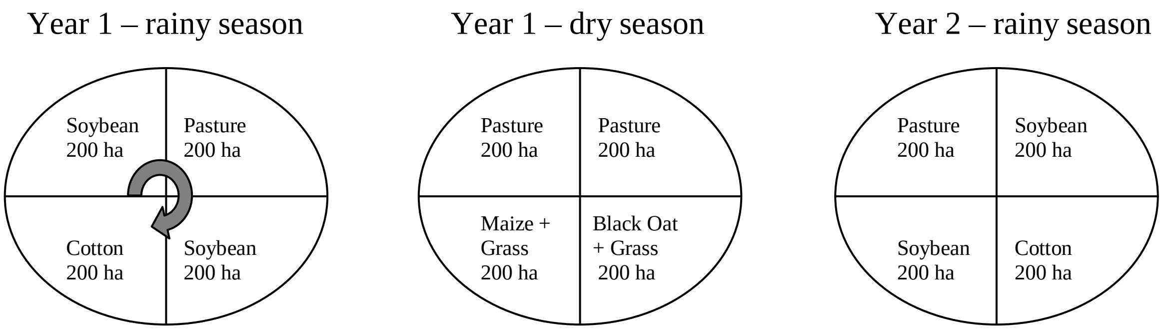

Figure G. 1 Representation of farmer 11's cattle-cropping integrated system (CCIS)

The rotation produces soybean, cotton and maize; the latter conjointly with grass so that once the crop is harvested the herd can graze the paddock (Figure G.2.b). He also had 6 ha of eucalyptus that was recently harvested. Regarding the cattle, he shifted from a rearing and fattening system to a complete cycle as he predicted an increase in prices for weaned calves. His herd of 900 crossbred cattle are all identified but not formally traced. He finishes 650 head, on average, with a slaughter age ranging from 20 to 30 months. However, he is considering producing 'super-early' cattle (e.g., finished at 14 months of age).

(a) (b) (c)

Figure G. 2 Crossbred cow/calf herd (a), maize on pasture (b) and no-tillage soybean (c)

Farm management

Farmer 11 is quite provident in his management style. Several of his strategies are focused on quickly responding to any change. Examples include having four wind turbines and four above-ground bunkers for silage when he actually needs half of each. This approach is extended to the finances as he seeks to maintain a reasonable amount of cash to purchase inputs whenever prices are attractive and not necessarily just when needed.

He has been more cautious about risk taking than in the past as he is looking for security. Such a view on risk reflects also on his commercialisation strategies. He is member of three cooperatives to buy inputs and sell his produce at good prices. These strategies are particularly important to ensure good margins to this farmer as he runs his farm with his own capital. One result of this farmer's close attention to commercialisation is his awareness of operational costs. He keeps records of cash costs, allocated per activity (cattle and cropping), including infra-structure maintenance. He also keeps records of birth and weight gain; the latter is used to select heifers to replace culled cows from his breeding herd.

His main sources of information are EMBRAPA and the MS Foundation (crop-related research institute). He participates in field days, seminars and training courses. Talking to other farmers is also important.

Technological profile

Overall technology adoption rate: 61%
Production technology adoption rate: 67%
Environmental technology adoption rate: 44%
Managerial technology adoption rate: 64%

Motivations and barriers for technology adoption

Farmer 11 had 61 percent of overall adoption rate, which placed him among the group of moderate adoption level. Production and managerial technologies are more appealing to farmer 11 than environmental ones. Although his adoption of environmental practices was 44 percent, he adopts some environmentally friendly innovations that were not included in this study such as low toxicity insecticide, no-tillage sowing and cattle-cropping integrated system.

In a broader sense, though, this farmer is very innovative and called himself a 'pioneer'. He aims to be in the forefront of innovation and states he does not wait for other farmers to adopt technology. Often, he develops and tests new technologies himself. This was the case for cattle-cropping integrated system: he has been doing it for more than 20 years whereas the vast majority of farmers are only recently considering its adoption. Other examples are no-tillage cropping and the use of homeopathy for tick and parasite control.

The main aspects this farmer looks at when considering technology adoption are economic return, soil profile improvement, increase in weight gain and stocking rate, reversibility and risk. The **economic return** of technologies is a major parameter for decisions. This farmer does not focus on short-term results only and often decides on technology that has lasting impacts, even when it is more expensive (e.g., less toxic insecticide). **Improving soil profile** is another decisive criterion on this farmer's choices over crops for a rotation, grass species and the beef activity itself as part of his farming system. Although farmer 11 claims beef cattle have a lower return than cropping, he believes cattle *"play their role in the system particularly improving soils conditions and breaking the crop disease cycle"*. Another aspect this farmer takes into account when assessing a technology is the **increase in production and productivity** via higher weight gain and stocking rate, respectively.

The **risk** associated with technology adoption is constantly assessed by farmer 11, who claims he has been more risk averse than in the past. His decision to use CCIS was a strategy to mitigate risk of price fluctuation and unsuccessful harvest of cash crops. A shift to cow/calf production was another decision to control the risk involved on being reliant on the weaned calf market (and prices). To a lesser extent, technology **reversibility** is an additional aspect this farmer might analyse before adoption. In other words, he analyses the ease, or flexibility, of discontinuing a technology once he adopted it.

Other criteria might lead farmer 11 to discontinue or prevent adoption. The **workload distribution** across the seasons, for instance, is important to this farmer because of the character of his farming system. A technology that requires excess workload may not be adopted to avoid an imbalance among concurrent activities. According to this farmer, the cow/calf system may be discontinued in the future because it competes with the workforce at demanding times on the cropping fields. Technologies that do not respect the **environment and animal welfare** are not adopted by this farmer (e.g., high toxicity insecticide). Other criteria he also comments on, but briefly, are the **difficulty in handling** technology (e.g., rotational grazing) and the high cost of implementation and maintenance (e.g., a Eucalyptus plantation).

From a social perspective, other farmers and researchers are the main influence on his adoption behaviour. His son-in-law, who is an agronomist and consultant, has also been helping him. Other consultants play their role too, often being not only influential to, but also influenced by, this farmer. During the interview, for instance, two consultants at different times visited him to ask for his opinion on agricultural issues.

Farmer 13

Background

Farmer 13 is 75 years old, married and has four adult children, all of whom are working alongside him. This farmer has secondary education, was retired from his professional job, and makes his living out of farming. He has over 44 years of experience in cropping, being 30 years conjointly farming beef cattle and working full time. He declares he is passionate about agriculture and does not think about diversifying into off-farm activities.

History

Coming from two generations of agriculturalists, this farmer not only enjoys agriculture but also developed a particular taste for machinery. His professional life started as a tractor driver, after buying a tractor shared with a relative. Part of his income was used to buy more tractors, lease land and start his own crop production. The business progressed since then and farmer 13 has several farms totalling more than 10,000 hectares, mostly with cropping.

Farming system

Although farmer 13 has also been producing beef for 30 years, it was not until 1994 when he found the most suitable production system for his farm conditions: the cattle-cropping integration system (CCIS). Farmer 13 argues CCIS is ideal because both activities work in synergy resulting in soil improvement and erosion control. The impact of this system for beef production, in particular, is a high pasture carrying capacity, supported by residual effects of crop fertilisation and nitrogen fixation by legumes (e.g., soybean).

Farmer 13's beef production is established on two farms, totalling 4,400 ha. Farm 'A', with 1,400 ha, operates as a stud, holding the breeding herd. It produces young certified *Brangus* bulls as well as cow-calf (1,200 hd). On this farm, purebred *Brangus* cows are inseminated with high profile *Brangus* bulls while commercial cows (*Nelore*) are inseminated with Red Angus. All calves are under creep-feeding. After weaning, all crossbred calves and some *Brangus* calves are sent to Farm 'B' to rear and finish. This farm comprises 3,000 ha and, on average, 3,725 head. The production system consists of three years of cropping, established through a no-tillage system, followed by pasture. In general, farm 'B' has 900 ha of cropping and 1,400 ha of pasture; the latter mainly under a rotational grazing system. Within pasture areas, farmer 13 also had 300 ha with integrated grass-legume cover. The overall result of this system is a carrying capacity of 2.7 hd/ha and an annual production of, on average, 2,200 finished cattle within 24 months.

Farmer 13 is committed to cattle welfare and believes animals should not lose weight at any time. His supplementation scheme illustrates this. Besides good pasture quality all year round, the entire herd are supplemented during the dry season, with the diet being established according to cattle age, availability of agricultural residues and other feed sources (e.g., hay and silage). During the dry season, all cattle are finished in an open-air feedlot whereas during the rainy season some animals are also finished on high quality pasture (Figure G.3.a) with supplementation (semi-intensive system). Another example of this farmer's concerns with cattle welfare is his corral structure. The corridors are fully covered on both sides to reduce cattle stress (Figure G.3.b), the ground is gravelled to provide hygiene and comfort and there is a horizontal dock to prevent cattle from hurting themselves during a truck loading (Figure G.3.c). He also left several forest buffer areas (Figure G.3.d) to provide cattle with shade.

(a) (b) (c) (d)

Figure G. 3 Several examples of technologies adopted by farmer 13

Farm management

It follows from such a production system that this farmer is focused on improving efficiency. From a managerial standpoint, this translates into a routine of keeping technical records and using them for decision-making. Several aspects are controlled on spreadsheets, for instance, birth, death, salt consumption and weight. The main performance indicator for decision-making is weight gain. Depending on this, farmer 13 makes decisions on pasture management and supplementation and selects suitable animals for the feedlot.

When it comes to finances, however, farmer 13 is more relaxed. Although he keeps records of expenditure and sales for tax purposes, this information is not used for economic analysis. He believes the business is doing well and there is no major reason to be meticulous with financial control. He added that he had no partners requiring performance evidence. While he acknowledges he manages finances on an intuitive basis, he bears in mind that he is almost debt-free. He does not like to be in debt and keeps borrowings deliberately low (1% of total assets). The main conditions that may lead him to borrow money are the necessity for investment or working capital he cannot afford by himself, and a low interest rate.

The management of farms ‘A’ and ‘B’ is supported by a consultant, who is in charge of operational management, whereas farmer 13 is responsible for tactical and strategic decisions. This technician is an important source of information for farmer 13’s decision-making since they discuss ideas frequently. Other sources of farming information are EMBRAPA research centres and other farms farmer 13 visits. Additionally, he reads agriculture-related magazines and attends several seminars and field days.

technological profile

Overall technology adoption rate: 76%
Production technology adoption rate: 87%
Environmental technology adoption rate: 75%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

Farmer 13 is among the group of top innovators, mainly as a result of his high level of adoption of production and environmental technologies. When it comes to managerial technologies, farmer 13 had a moderate adoption rate as a result of his lack of knowledge in this area, and therefore, a lack of priority.

As discussed previously, the farm manager played an influential role on farmer 13's decision-making. Farmer 13's sons are also consulted when he is making decisions, particularly when related to cropping. Additional 'important others' are other farmers, with whom he interacts both formally and informally. He participates actively in the local rural union, cooperatives and a couple of farmers' associations, often as a member of the board of directors. Being a member of APYS and BrazilianGAP also impacts on his technology adoption decisions as he tries to cope with the programmes' regulations.

It follows from this context, that farmer 13 often visits other farms when considering technology adoption. He also **experiments** with technology, using his knowledge and creativity to adapt it to his conditions. When he decided on developing a feedlot, for instance, he visited several farms to learn about feeders. After a while, he chose the most suitable feeder design and improved its concepts to meet his needs.

A major goal this farmer holds is his focus on efficiency improvement and an increased **turnover**. His technology adoption pattern is highly influenced by this aim as he is constantly seeking to make the best use of available resources and, simultaneously, shorten the cattle production cycle. Several practices are undertaken to achieve such a goal - he shifted from buying weaners to 18 months heifers because these are closer to slaughter age and returns on the investment are faster; he decided to sow pasture on crop land using an airplane so that he did not need to wait until crops are harvested to have grass established; and he supplemented the entire herd during the dry season. The latter was a strategy to both increase turnover and efficiency since farmer 13 has crop residues available.

Pasture carrying capacity is another influential factor on decisions. This factor caused farmer 13 to start a cow/calf production on farm II where carrying capacity is high, whereas he limited the breeding herd size on farm I where soil conditions are poorer. The feedlot period and supplementation are also defined on the basis of pasture carrying capacity since pasture is always preferable.

Other factors this farmer takes into consideration for technology adoption are **technology compatibility** and **cost-benefit**. If farmer 13 judges a technology as incompatible with his farming system he immediately eliminates it from his pool of alternatives. In turn, if an innovation is compatible and the analysis proceeds, he looks at the cost-benefit. For instance, he decided to adopt heat synchronisation because it has affordable costs and results in a concentrated birth season and standardisation, easing cattle handling.

New technology is not considered if farmer 13 is **satisfied with his current system**. This is the case of his financial management as well as his unwillingness to diversify into forestry. According to this farmer, both could potentially improve his farm financial performance but he paid little attention to them because he is happy with what he achieved so far.

Farmer 17

Background

This 34-year-old farmer is married with one child. He graduated in Animal Science and worked for an animal nutrition company for five years. He lived on the farm and had a house in town, where he went once a week. Farming is this farmer's only source of income. Farmer 17 is passionate about farming and claimed his bond with the land comes from family tradition.

History

Farmer 17's grandfather was the original farm owner and handed it over in 1968 to this farmer's father. Despite being the legal owner, his father let him manage the farm. Both father and son shared strategic decisions whereas tactical and operational issues are resolved by this farmer only. He claimed, though, that his father's participation has been decreasing as he is getting older and less involved with the farm. At the time of interview, farmer 17 had ten years of farming experience.

Farming system

The production system consisted of a complete beef cycle, including a stud unit. The total herd is 3,000 head (1,200 breeding cows), with one third being *Nelore* purebred. The farm had 2,525 ha in total, of which 2,000 ha are pasture, mostly under rotational grazing. He also leased three properties nearby where he had another 1,000 stock. In general, both commercial and genetic herds are maintained under the same regime. When heifers achieved 24 months of age (first mate) and steers, 18 to 22 months (castration age), cattle are separated into different groups. The top genetic herd are sent to the best paddocks and are supplemented. Bulls that did not qualified among the top genetic group are castrated and joined the commercial herd, where all steers are also castrated. Part of the commercial heifers herd is inseminated, often with crossbred bulls, whereas the remainder are under natural mating.

Regarding the cattle's diet, the strategy varied according to the season, animal's gender and age group. During the rainy season, the rearing heifers are on pasture and supplied with mineralised salt, while the rearing steers are also supplied with energy-salt complex to support a faster weight gain. During the dry season, both categories are sent to a feedlot where farmer 17 provided them with sugarcane and protein-salt complex. Most finishing cattle are under rotational grazing and supplementation with concentrate feed all year round (semi-intensive systems). Some finishing heifers, though, are maintained on pastures only if grass is available and if farmer 17 had no need to fatten them faster. Annually, he finished around 825 cattle and sold 175 young bulls and breeding cows.

Farm management

From a managerial perspective, farmer 17 kept both technical and financial records. The farm is enrolled in ERAS and had its purebred herd registered with ABCZ. This implied farmer 17 had to comply with these programmes' requirements, even though he found it boring and time consuming. He kept notes of artificial insemination dates, births, deaths and sanitary practices, which are later transferred to a piece of software to generate performance figures. He also had Excel spreadsheets where he controlled his cash flow. This included all direct costs and investments as well as sales. He did not work out the cost of production, however.

Farmer 17's main sources of information are beef-related magazines, training courses and seminars. He also liked to discuss ideas with other people, such as researchers, input salesperson and other farmers. Farmers, in particular, are very relevant in his context since he had several of them visiting his farm every year because of the high genetic herd. In these opportunities, he asked them for feedback on his practices he has been doing and suggestions for improvement.

Technological profile

Overall technology adoption rate: 75%
Production technology adoption rate: 84%
Environmental technology adoption rate: 63%
Managerial technology adoption rate: 64%

Motivations and barriers for technology adoption

A high level of adoption is observed for production technologies, along with moderate adoption rates for environmental and managerial technologies. Farmer 17's commitment to manage all farming aspects properly placed him among the group of farmers with the highest level of technology adoption.

When considering technology adoption, this farmer **visited** other farms to get ideas from, particularly when the intended investment is large. Additionally, he **experimented** with technologies on a small scale before full implementation in order to learn how to deal with any problems and confirm results. Some examples are his trials with crossbreeding, sugarcane use in the feedlot and veterinary products.

His decisions on technology uptake are primarily related to a **cost-benefit** analysis. Farmer 17 looked at the purchase price (or cost of implementation) and beef prices for such an analysis. His annual decision on whether or not use the feedlot, for instance, depended on supplementation costs and predicted returns. These are based on the expected beef prices for the year. This example illustrated that farmer 17 sought to maximise margins, as he claimed beef enterprises have low profitability. It follows from such a view that high **purchase prices** may stop technology adoption, or result in its interruption, either because the cost-benefit ratio became unfavourable, or purchase prices became prohibitive. Some examples are the discontinuation of pasture fertilisation and the change in the phosphorous content in the mineralised salt when these input prices rose. On the other hand, when beef prices went up he felt motivated to increase his technology adoption level.

Logistics and staff limitations, particularly during busy times at the farm, are criteria that farmer 17 also considered when analysing technologies. Concurrent activities demanding a workforce and machinery led him to prioritise one activity over another, resulting in technology discontinuation. This is the case of creep-feeding: it is discontinued because it is competing for staff and machinery when both were in high demand in the feedlot and in the semi-intensive systems.

Farmer 17's technology adoption and non-adoption behaviour is influenced by **market requirements**. He reported several practices he had to, or could not, use in order to comply with 'clients' needs. Examples include his choice of a particular bull for artificial insemination because of his clients' preferences and some technical controls he puts in practice to comply with traceability and breeds registration systems.

Farmer 18

Background

Farmer 18 is 64 years old and had 40 years of farming experience. He is retired, married and has three adult children: two daughters and one son. Farmer 18, his wife and their son are all agronomists and helped with the farm management. The family made their living out of farming.

History

Farming is a family tradition for farmer 18, whose great-great-grandparent is a farmer, followed by his successors. His family arrived in the region in 1870, helping to establish the first settlements there. Farmer 18's father, who is also a farmer, bought this property in 1962. In 1969, farmer 18 started helping his father, taking over the farm in 1974. Recently, he started preparing his succession plan and has been slowly involving his son in farming decisions.

Farming system

This family farm had 10,000 ha of which 4,000 ha are under conservation and legal reserve areas. The farm is enrolled in ERAS/SISBOV and cattle are all traced. Pasture area consisted of 5,000 ha, supporting 5,500 cattle under a complete cycle system. Continuous stocking is the predominant grazing system (60 percent), with the remaining area being established under a rotational grazing scheme. Farmer 18 produced maize for both silage and grain in order to be used in animal feed. He also had sugarcane to supply cattle during the dry season. In general, supplementation is restricted to this season as well. With regards to reproductive aspects, this farmer established a mating season from June to October, with part of the breeding herd on natural mating (using *Nelore* and *Guzerá* bulls) and the remainder on artificial insemination. In this case, farmer 18 uses bulls of various breeds to crossbreed with *Nelore* cows and take advantage of heterosis effects. The average age at first calving is 34 months whereas the age at slaughter varied from 30 to 36 months. The annual production is 2,100 head. Farmer 18 also had 150 sheep for self-consumption only.

Farm management

With regards to information management, farmer 18 employed simple technical records, but did not estimate performance indicators. Such records are basically designed to provide him with stock control. Additionally, sanitary practices are also controlled. When it comes to financial controls however, records are more detailed. He controlled cash flow monthly, estimated operational costs, including depreciation (but not opportunity costs) and calculated the business margins. Such information is used for decision-making, particularly investment-related. It is also assessed when he is considering borrowing money to finance farm operations.

Technological profile

Overall technology adoption rate: 77%
Production technology adoption rate: 80%
Environmental technology adoption rate: 75%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

Farmer 18 presented a high level of technology adoption across all clusters of technologies, resulting in a high average adoption level. This farmer is passionate about farming and had a strong commitment to pass this family farm to his children in better conditions than he got. For this reason, he sought sustainability in a broad sense, including production, administration, human resources and environment. This famer's view supported the adoption of such a wide range of technologies.

The main factor that encouraged this farmer's technology uptake is **return on investment**: technology is only adopted if returns are positive. Fluctuations on prices, therefore, impacted this factor and, depending on the direction of the change, led farmer 18 to various courses of action. Increases in beef prices, for instance, positively affected adoption. The fact that farmer 18 implemented traceability systems illustrate this, as he expected traced cattle to get higher prices. Increases in input prices, in turn, resulted in non-adoption or discontinued adoption. This was the case with a reduction in maize plantation as input prices increased.

Return on investment is often taken as a comparative analysis between similar options. In this farmer's view, the return on investments in embryo transfer, for instance, is not worth it, as he found buying high profile tested bulls is cheaper and less **risky**. He also made comparisons among various technological options in order to decide on the priorities for investment. Returns on investment, along with the removal of barriers for production, are the decisive criterion.

Another economic-related aspect that influenced farmer 18's technology adoption level is **beef profitability**. He claimed that the profitability of the beef enterprise in a given year influenced the level of investment he is willing to take the subsequent year. A typical example he cited is pasture fertilization: he only invested in fertilization when there is a surplus the year before. Other factors also influenced farmer 18's willingness for investments, such as land tenure insecurity and the international crisis. Both **external factors** created some insecurity in markets worldwide, increasing risks. In such an environment, this farmer decided to be more cautious and hold back his investments.

Technology **compatibility** is another aspect farmer 18 analysed, rejecting any technology seen as incompatible with his farm system or conditions (e.g., *Estilosanthes*). Technology is also discarded if **staff limitations** are unforeseen and could not be overcome. This is the case of the non-adoption of more detailed control system for technical aspects.

From a social perspective, decisions are influenced by family member, particularly, farmer 18's wife and their son. Although farmer 18 admitted he is the main decision-maker, his family's ideas and insights are relevant to the final outcome. He also liked to listen to other people, particularly staff.

As farmer 18 cherished the learning process, he, his son and some employees often went to training courses and seminars. To keep up to date, he also read magazines and discussed farming-related issues with other farmers and researchers. He is politically involved with rural representatives and several producers' associations and cooperatives. Such social engagement provided this farmer with not only a source of farming information but also with the opportunity to operate at a higher level to support the cropping sector as a whole.

Farmer 26

Background

Farmer 26 is an agronomist with a Masters in Animal Science. He is 58 years old and had 29 years of experience as a beef farmer. He is married and has two adult children; none involved with farming. He worked for a beef-related company where most of his income came from (67 percent). Farming provided him with the remainder 33 percent of income. He is passionate about beef production and is looking forward to retirement so that he could spend more time at the farm.

History

Farmer 26's involvement with beef cattle started within his family, since his father is also an agronomist and a beef farmer. Such a background, along with his passion for farming, influenced his career choice (animal sciences), which he has been dedicated to for 34 years. In 1979, the farmer's wife received the 1,400 ha farm as inheritance. Since then, he started developing the farm, introducing more productive pastures, building infra-structure and improving cattle genetics. The result is an increase in performance, with annual production of calves boosted from 100 to 420 head.

Farming system

Farmer 26's farm is specialised in cow/calf production, with 986 head (550 breeding cows) under rotational grazing on 700 ha of pastures. *Nelore* breeding cows are mated with *Nelore* bulls during the mating season (November to January), with an average pregnancy rate of 80 percent after pregnancy test. Non-pregnant cows are culled. At weaning, all male calves are sold; their price is established by farmer 26 based on their weight and not per head, as it is usual in that region. According to this farmer, his calves are heavier compared to the average calf at the same age in that region, justifying this practice. Female calves, in turn, are reared up until two years of age. At this age, heifers are selected as replacement for breeding cows on the basis of their weight and breed traits. Culled heifers are sold as store cattle to other farmers.

Farm management

This farmer's main objective is to hand over the farm in better conditions than when he got it. In terms of management, this implied he sought constant improvement. To accomplish such a goal, farmer 26 stressed he is meticulous with the farm organisation and liked to have things scheduled, organised and controlled. As a result, he managed the farm based on actual farm data. The herd is individually identified, allowing him to analyse cattle performance, including birth and death rates, sanitary conditions (e.g., disease treatment) and weight. Paddocks management, such as pasture reform and maintenance, is also recorded to provide farmer 26 with historic use and handling of areas. From a financial-economic standpoint, this farmer used a piece of managerial software where he not only kept records of sales and purchases, but also simulated investment options. At that stage, he is able to calculate only economic margins but is implementing a piece of software to work out the cost of beef production.

Technological profile

Overall technology adoption rate: 59%
Production technology adoption rate: 52%
Environmental technology adoption rate: 50%
Managerial technology adoption rate: 80%

Motivations and barriers for technology adoption

Farmer 26 had moderate adoption levels of technology in general, and of production and environmental technologies in particular. Clearly, his priority laid in managerial technologies, whose adoption rate is the highest for this farmer. To put in his own words: *"if there is a field I am definitely innovative is in farm management"*.

Farmer 26's system of production is settled and he only considered changes if he is **unsatisfied** with particular issues on his farm. He prioritised these issues in order to tackle them gradually, according to their **urgency** and to his **financial constraints**. Once the issue is identified, he searched for alternatives by visiting other farmers, talking to researchers and browsing information in magazines, scientific articles and websites.

This farmer did not like to take **risks** and called himself *"a bit conservative"*. His philosophy is to adopt only consolidated technologies, whose results had been confirmed and pitfalls addressed prior to his adoption decision. For this reason, he did not run small scale trials. His conservative characteristic is also highlighted by his aversion to borrowings. His rule of thumb is: *"no money, no investment"*. With regards to technology adoption, this rule determined one of this farmer's criterions for decision: **cost** of implementation and maintenance of technology. He only adopted innovations he could afford.

Another major criterion for decision-making is **return** on investment. Potential economic returns are a motivation for this farmer's technology uptake. He claimed that beef production has low profitability so any increment on returns is important. In contrast, technologies whose returns are unclear are not adopted (e.g., traceability system, crossbreeding and creep-feeding for calves).

From a production standpoint, one criterion farmer 26 looked closely at is the effect of technology on **reproductive efficiency** (pregnancy rate). Since he had cow/calf production, reproductive efficiency impacted not only the production itself, but mainly the profitability of the entire system. The low pregnancy rate resulting from artificial insemination illustrated this farmer's concerns and justified his non-adoption behaviour in this case.

Other aspects farmer 26 assessed when considering technology adoption are technology **compatibility** with current production system, impact **on staff demand** and requirement for skills development. If innovation is taken as incompatible, no further consideration is made and technology is eliminated. However, if technology is compatible, farmer 26 analysed his capacity to cope with those additional aspects. The **difficulty** of using technology is another factor that this farmer analysed. The harder an innovation is to handle, the least likely it is to be adopted (e.g., pasture diversification and legume/grass mix). On the other hand, ease of use, although positive, is not a sufficient condition to justify adoption (e.g., traceability system).

Although farmer 26 is not formally involved with groups of farmers, his professional career provided him with opportunities to constantly interact with beef researchers, consultants and farmers. In his opinion, this played a decisive role on his management practices and adoption behaviour. Additionally, he claimed he liked to involve staff in his decision-making process, asking for their views and feedback. His wife is only involved in decisions when they consisted of large investments or strategic decisions that may impact the family as a whole.

Factor 2 – The Committed Environmentalist

Farmer 02

Background

Farmer 02 is a 52-year-old civil engineer who specialised in marketing, is married and has two adult children, none of which are within the agricultural sector. As part of farmer 02's parents' succession plan, each of his five siblings received a farm. Farmer 02 inherited his farm in 1993. Prior to that, farmer 02 had worked for 25 years in a real estate group and had managerial roles. After a stressful financial time, he decided to take over the farm. At the time of the interview, he had 15 years of experience in farming.

Farming system

Initially, he started with cattle production on his 1,430-hectare-farm but later decided to implement ecotourism, whose management has been shared with his wife. He bought another two farms (420 ha and 50 ha), both with tourist attractions and, one of which, had agro-forestry being implemented. About 85 percent of his total income came from the tourism operation and 15 percent from beef cattle production, although he had voluntary off-farm activities as well. He lived in town with his family, visiting the farm once a week.

This farmer's ecological views have been remarkably influential to his farming system. His philosophy is to make nature 'work' for him, observing its natural processes and incorporating them into his farming system. According to farmer 02, this has been an ongoing learning process, requiring constant observation and adjustment. In order to further develop his theories, he started reading about farming and environmental issues. His main sources of information are EMBRAPA, books and articles, internet, training courses and seminars. He also counted on private consultants' support.

A consequence of this dynamic learning process is the fact that his farming system is not stable and is being developed gradually over the years. Originally with native pasture, it has all been replaced by improved sown pastures, allowing stock to increase from 200 to 950 AU. The production system consisted of a complete cycle under a rotational grazing system, with 1,200 head on 1,020 ha of pastures. The farm, in general, had poor soils and farmer 02 has used legume and grass mix to improve soil fertility and recover paddocks. He finishes around

416 head per year, on the average, at 24 months of age. The herd is all traced, controlled and, every six months, evaluated by accreditation bodies.

Farmer 02's farm is highly diversified. Beside beef cattle and ecotourism, he also had horticulture, 30 milking cows, 60 poultry, 260 sheep and 50 pigs. The agricultural produce supplied the tourism operation, which, in turn, helped these activities, providing meal leftovers (for the pigs and poultry) and waste that is processed and used as fertilizer on pasture and horticulture. He is also implementing a cattle-forestry integration system, initially on 14 hectares, which he intended to expand to the whole farm. In his view, this project is innovative because he is planting native trees instead of the conventional pine or eucalyptus.

Farm management

Regarding his management style, he called himself *"unconventional"* since he likes doing things differently, experimenting and innovating. 'Learning' is a key word for this farmer who is eager to observe how natural processes occur and how they could support his production system. He claimed his beef production is more 'ecologically balanced and sustainable' than his neighbours. Although he argued that he tries to find a balance between profitability and nature, ultimately, he admitted he often chooses that which gives him more satisfaction and not necessarily more profit. For instance, he preferred to run a complete cycle beef system, even though he believed the return on investment is possibly smaller than other systems, the reason being that he did not like the bargaining process involved in buying and selling cattle.

He centralised the controlling tasks although he believed he should delegate more. He controlled only a few technical aspects (e.g., birth, weight, vaccination). On the other hand, he claimed his financial control is more sophisticated than the majority of farms. He applied concepts from his former experience with non-farming businesses. He did not like to borrow money to finance fast improvements of his farm and, at the time of the interview, had no loans. Instead, he wanted his farming system to evolve gradually while he learns.

Technological profile

Overall technology adoption rate: 75%
Production technology adoption rate: 68%
Environmental technology adoption rate: 100%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

Farmer 02 is one of the top farmers, having the highest overall technology adoption rate and one of the highest adoption levels for environmental technologies amongst all the farmers. His adoption rates for managerial and production technologies are also high, showing that this farmer balanced business and environmental objectives. This is consistent with this farmer's policy of using 'mother nature on his behalf'.

For a technology to appeal to this farmer, it must fit into his farming system and, in particular align with his environmental values. The other important aspects farmer 02 assessed are the technology testability, ease of use and his cash availability. He usually **tested** and observed technologies on a small scale in order to learn about them before implementation. This is particularly important because he liked to innovate (i.e., do things differently) and operated on a trial-and-error basis. In this way, he could manage the risk better.

In addition, farmer 02 argued technology needs to be **easy to use** and facilitates the logistics within the farm. Since beef production is a secondary activity in his case, he could not spend much time on complicated and demanding technologies.

Cash availability is another aspect that influenced not only adoption of technology but also non-adoption and discontinued technologies. Since this farmer's policy is to avoid borrowing money, he relied only on his own capital. Consequently, if he ran short of cash, he avoided or delayed adoption of new technologies and/or reduced the scale of other technologies that are already in use (e.g., concentrate and fertiliser).

Farmer 02 believed his social interactions with other groups of people are important. He asserted that, as he interacted with people, he had opportunities to learn about different systems of production, different challenges in farming and, ultimately, different people's viewpoints. This view justified this farmer's high involvement with many formal social groups, such as associations and NGO's, during his life. He reported about 30 percent of his time is dedicated to voluntary services at an NGO and two associations. He is also a member of APYS, but is not as dedicated to this as he is to the other organisations. He claimed that they all, either directly or indirectly, played their role in his decision-making process.

Farmer 16

Background

Farmer 16 is 70 years old, married and has four children, none involved with his farm. He is an accountancy technician and had 45 years of experience in farming. He is passionate about it and claimed his farm is his joy in life. He had several serious health problems that, along with his age, is making him slow down with farm operations. Though, he stressed he did not intend to stop farming as his income came entirely from farming.

History

His family tradition with beef cattle is the origin of his bond with land and animals. Farmer 16 started farming in 1963 in his father's farm. He cleared the farm and sowed rice that is later replaced by pasture. After his father passed away, he inherited 800 ha and financed the farm development. In the 1970's and 80's, he capitalised on land, reaching 3,000 ha. For unfortunate reasons, he had to sell part of the farm to avoid bankruptcy.

Farming system

With 1,500 ha left of his original farm, farmer 16 leased 700 ha in 2003 for other farms to grow soybeans. The remaining area, excluding the legal reserve, is dedicated to rearing and finishing cattle. His system of production consisted of buying and selling *Nelore* heifers under APYS contracts, finishing around 500 head annually. Farmer 16 usually bought cattle with 18 to 20 months, selling them 10 to 12 months later. Around 600 cattle are on continuous grazing all year round, being sent to 'finishing' paddocks (i.e., good quality pasture) when they reached 340 kg of liveweight. If farmer 16 believed he could get some return on supplementation, he supplemented cattle for 30 days prior to slaughter, allowing heifers to finish with 390 kg of liveweight. A major problem farmer 16 is facing is pasture degradation, with some paddocks highly degraded.

Farm management

Farmer 16's financial constraints reflected in his investment capacity and therefore his ability to reform pasture and improve production. From a managerial perspective, this meant the farmer's strategy is to survive in the business by keeping expenditures to a minimum level. However, he claimed he has been struggling as costs have grown more than revenue. Although he did not formally work out these figures, his intuition is that he is working in the red. The only measurement farmer 16 used for managerial purposes is cattle weight.

This uncertainty around the farm financial health brought uncertainties about the farm's future. His struggles with cash flow have, to date, been limiting the farm improvement. He argued that whether or not he will be able to overcome this relies on favourable farming policies as well as higher beef prices in the future.

Technological profile

Overall technology adoption rate: 21%
Production technology adoption rate: 7%
Environmental technology adoption rate: 25%
Managerial technology adoption rate: 36%

Motivations and barriers for technology adoption

Farmer 16's low level of adoption is in general a reflection of this farmer's struggles with finances. Technologies that farmer 16 is adopting are those that he believed are either, completely essential to production, or, that had no direct cost involved (e.g., technical records).

In the context that cash flow is a major driver of this farmer's adoption behaviour, **input and beef prices** became the main criteria for decisions. If he perceived technology as 'expensive' he is unlikely to adopt. Also, **unclear returns** on technology prevented him from adoption. On the other hand, increases on beef prices motivated him to uptake technology. Cattle supplementation, for instance, are entirely price-sensitive: if beef prices went up, he supplemented, and if they went down, he stopped. In contrast, if supplement cost went up, he stopped supplementation, whereas supplementation was supplied if prices went down.

Besides price-related aspects, personal aspects influenced his adoption behaviour. Farmer 16's age, along with his health problems, brought some physical and psychological limitations to his farming style. He did not want to increase his **workload** or **risk** and is not as enthusiastic as he used to be about learning new farming techniques. Additionally, because of his age, he claimed **long term results** did not interest him anymore (e.g., forestry). Therefore, technologies that did not meet these requirements are unappealing to farmer 16.

Being a formal member of APYS motivated farmer 16 to adopt some technologies. To meet this Association's requirements on traceability, farmer 16 bought ear tags to identify cattle individually. However, it is his informal interaction with farmers from APYS and other farmers that provided him with useful insights in farming.

Factor 3 – The Profit Maximiser

Farmer 12

Background

This farmer is 69 years old, married, retired and had secondary education. He lived in town with his wife and visited the farm once a week. He has four children, one of whom is helping the farmer in one of his two farms. He is born in Southern Brazil and, in the 1980's, moved to *Mato Grosso do Sul* State in order to provide his children with a good education.

History

He had been farming for 27 years when he bought his first farm (Farm 'A'). He used to produce cash crops, watermelon and coffee, and had a small beef cattle herd. At that time, he also had a grocery shop in town. In 2001, he decided to sell his business in town, stop crop production, and dedicate himself to beef production, since it is safer and less demanding than the other activities. He bought a second, smaller farm (Farm ‘B’), where part of the production is carried out.

Farming system

The overall design of farmer 12’s farming system is based on an integration of farms ‘A’ and ‘B’, with farm ‘A’ holding the cow/calf herd and farm ‘B’ the rearing and fattening phases. Farm ‘A’ had 950 ha, of which 750 ha are sown pastures. The cow/calf herd consisted of 900 head, of which 600 head are breeding cows. Weaned calves are all transferred to farm ‘B’ after weaning. On this farm, they are reared and fattened on 430 ha of pastures, some under rotational, others under continuous grazing systems. Farm ‘B’ had 552 hectares, in total, with an average herd of 780 head.

Within each farm, the farming system is adjusted to local conditions. Since farm ‘A’ had poor soils, that are incompatible with fattening, the cow/calf activity is established there. On this farm, breeding cows and bulls are under continuous grazing, while calves had access to creep-feeding systems. Under the breeding season, *Nelore* cows are inseminated with Brahman or Red Angus and, if empty afterwards, are mated with the farm bulls. Once weaned calves are sent to farm ‘B’, whose soils are more fertile, they are supplied with protein-salt complex and energy-salt complex during the dry and rainy seasons, respectively. When heifers achieved 300 kg of liveweight and steers 400 kg, both are supplied with concentrate feed to finish, with ages ranging from 24 to 30 months. Annually, farmer 12 produced 400 cattle for slaughter, all of which are traced.

Farm management

Farmer 12 kept technical records, such as births, deaths, weight at weaning and weight gain. The latter is used to evaluate supplementation efficiency (e.g., feed conversion).

When it comes to farm finances however, farmer 12 claimed he managed the farm mostly based on his intuition. Although he kept receipts, he did not use them for cash flow control. Knowing the cost of his beef production is irrelevant in this farmer’s opinion as he feared he might realise he is running ‘in the red’. Such a fear also supported this farmer’s views on borrowings. He avoided borrowing money since he did not like the idea of having debts. However, he recently borrowed a small amount to reform pastures, because the interest rates were attractive.

This farmer’s main sources of information are cropping-related news, magazines and television programmes. He also learns about cropping through other farmers, salesperson and a veterinarian he occasionally hired. Often, he went to meetings with other APYS members, seminars and visited EMBRAPA research centres or other farms to check on innovations.

Technological profile

Overall technology adoption rate: 57%
Production technology adoption rate: 60%
Environmental technology adoption rate: 50%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

Farmer 12 had moderate levels of adoption for all types of technologies and, thus, on the overall adoption rate. This result reflected the farmer's aim of keep farming simple and easy.

During the entire interview, farmer 12 highlighted that **technology workload** and the **low quality/availability of workforce** are the two major constraints for technology adoption on his farm. According to this farmer, workload has been a limitation because of his age and the fact he did not live on the farm, thus, he cannot afford innovations that demand too much of him. The excess of workload led to the other limitation: quality and availability of workforce. He believed that if he had more employees and/or had more qualified staff he would be able to adopt more technology (or more advanced ones). Given his small scale of production and labour costs though, he claimed he cannot afford another employee.

These two aspects not only prevented adoption but also resulted, occasionally, in technology interruption. Some examples, where these aspects led him to discontinue technology/practice are: (1) he stopped watermelon production because it was very demanding; (2) he discontinued feedlot systems because there was not enough people to do this, and other activities, simultaneously; (3) he gave up on feedlot because of unprepared staff, who often did not feed animals according to the recommendations, resulting in poor animal performance.

In contrast, technology **ease of use** is particularly appealing to farmer 12. He shifted from dry concentrate feed to liquid ration as the latter is easier to handle during the rainy season, even though results are not as good as the former.

Besides these intangible aspects of technology, farmer 12 also analysed technical and financial impacts of technology before adoption. From a technical point of view, this farmer sought innovations that increased feed conversion and weight gain, consequently having positive effects on the **farm turnover**. This justified his adoption of crossbreeding and cattle supplementation, for instance. From a financial perspective, **returns on technology** adoption must be greater than its costs. This aspect motivated his adoption behaviour as much as it inhibited technology use if the context changed (i.e., unfavourable cost-benefit ratio). To illustrate this, farmer 12 commented he did not supply rearing cattle with concentrate feed because it did not give the best return (e.g., in comparison to the fattening phase). On the other hand, calves are on creep-feeding because, although he found it expensive, the weight at weaning is increased and cattle are finished more rapidly, over-compensating its cost.

The lack of machinery and the local government's lack of support are also factors this farmer claimed as barriers for his farm improvement. The former is a constraint since he could not carry out some technologies without appropriate equipment (e.g., he could not sow maize and produce silage). The latter is an external factor, not directly technology-related, but with spill over effects on adoption according to farmer 12. He claimed the poor maintenance of roads limited his investment capacity for a number of reasons: (1) difficult access to his farm; (2) pay road-related levy with no 'return on investment'; (3) often spending his own money to fix the (unpaved) road instead of investing in his farm.

Farmer 12's technology adoption decisions, from a social standpoint, have been influenced mainly by other farmers, researchers, and his consultant (veterinarian). Although these people did not bear responsibility on decision-making, they are a source of new ideas, triggering this farmer's willingness to get to know innovations better.

Farmer 14

Background

Farmer 14 is a 45-year-old civil engineer, who is married and has two young children. He ran a business in town, which provided him with all his income.

History

Farming is a secondary activity that he started in 2000, along with his three brothers. Together they leased a farm where they finished 4,500 heifers every year. He also managed one of his father's three farms, sharing this role with one brother. His other brothers shared the management of the two other farms as their father (79 years old) is exiting this activity. Consequently, the four siblings are taking over the farms, working together, as the farms are integrated within one major system of production.

Farming system

In order to understand this production system, the systems on farms 'A' and 'B' need to be described, even though these farms are in *Pantanal* region, thus, out of this study area. Farm

‘A’ is a stud, involving both commercial and breeding herds. Within the commercial cow/calf herd, part of the breeding cows (*Nelore*) is artificially inseminated under a crossbreeding system and the remainder being mated with *Nelore* bulls. All female weaners are reared on farm ‘A’: 20 percent for breeding herd replacement and 80 percent to be fattened (on farm ‘C’). Male calves had various destinations according to their genetics: *Nelore* calves are reared on farm ‘B’ whereas crossbred calves are sent straight to farm ‘C’, where they are reared and fattened. All calves from farm ‘B’ are then sent to be finished on farm ‘C’ as well. This is the farm where the interview took place and where farmer 14 is more directly involved.

Regarding the supplementation system, each category is under a particular strategy, depending on pasture carrying capacity, cattle age, bloodline and season of the year. The cow/calf herd (farm ‘A’) and the rearing calves on farm ‘B’ are supplied with protein-salt complex all year round, given the poor conditions of soils, thus, its low carrying capacity. Stocking rate on farm ‘A’, for instance, is 0.55 UA/ha. On farm ‘C’, pasture quality is higher so is its stocking rate (1.1 UA/ha, on the average). A consequence of better pasture quality is that rearing cattle are only supplied with protein-salt complex during the dry season. During the following rainy season, fast weight gaining cattle are selected and supplemented while still on pasture (semi-intensive system) so that they are finished before the next dry season. When the dry season started, any remaining finishing cattle are sent to a feedlot where they are fed with high levels of feed concentrate. The result of this system is an annual production of 2,200 head, with ages ranging from 20 to 28 months, and 800 culled cows.

Farm management

From a wide managerial perspective, this farmer is more focused on technical issues than on financial ones as he advocated that *“buying well and improving production is more important than having financial management”*. Although the farms had one central office in town to manage all paperwork, receipts are kept for taxation reasons only. Farmer 14 claimed his financial management is done on an intuitive basis, mainly taking into account the balance of his bank statement. In contrast, technical records are constantly analysed to provide farmer 14 with indicators of cattle performance (e.g., weight gain), from which he made his decisions.

This farmer’s main sources of information are seminars, cropping-related magazines and people involved with farming somehow. These people included two consultants that worked for him, an input salesperson, other farmers, his own siblings and his father. The extent these people influenced his decisions will be discussed in the next sub-section.

Technological profile

Overall technology adoption rate: 60%
Production technology adoption rate: 76%
Environmental technology adoption rate: 33%
Managerial technology adoption rate: 45%

Motivations and barriers for technology adoption

This farmer's level of technology, in general, is moderate and so is his adoption of environmental and managerial technologies. Clearly, his focus is on production technology, which had the highest adoption rate. This is consistent with this farmer's belief that production and profit are intimately related.

Farmer 14 is open-mind and enjoyed sharing ideas, discussing plans and deciding the best course of action. Major technological decisions (strategic level) are usually shared among him, his brother and their father. Tactical and operational decisions where mainly shared by the siblings only, as their father is not as involved with farming anymore. Other influential people on this farmer's decisions are his consultants and other farmers. Their main contribution has been supplying farmer 14 with ideas and information on innovations, which, in turn, become potential issues for further analysis and, often, implementation. His involvement with producers associations also influenced his technology uptake as he tried to cope with their policies or recommendations.

Before adoption, farmer 14 **visited other farmers** to check technology results. Additionally, he usually **experimented** with technology on a small scale on his farm. Performing his own experiments allowed for learning, testing and extrapolating results for cost-benefit analysis if indeed technology was to be implemented on the farm. **Bad experiences**, however, led him to disregard technology, with no further enquiries.

When considering technology uptake, **cost-benefit** is the main criterion farmer 14 assessed. His understanding of costs and benefits is primarily economic. From a cost perspective, farmer 14 considered the cost of technology implementation (i.e., purchase price) and maintenance, if applicable. Regarding technology benefits, he usually took into account the additional receipts (actual or predicted) generated by an increase on weight gain at actual or future beef prices. To justify technology adoption, benefits should be greater than costs and cost-benefit ratio for an alternative technology should overcome the cost-benefit of the technology in use. This rule applied in several decisions farmer 14 made, one example being his change of mineralised salt for cow/calf herd. He decided to shift from a cheaper option to a more expensive one, with high phosphorous content, but also with responses in weight gain greater than the former mineralised salt.

Additionally to the economic stance, cost-benefit is also undertaken in a broader sense, involving other tangible and **intangible aspects** of technology adoption. Since he is committed to long-term results, he is willing to afford some small losses in order to do better over a longer period of time. This justified the adoption of technologies that often breakeven, such as feedlot for finishing cattle. This strategy allowed farmer 14 to decrease grazing pressure since part of the cattle are removed from pasture, shorten the cycle of production and plan slaughters more accurately along the year.

Farmer 14 recurrently mentioned the importance of **shortening the cycle** of production and this is a major driver for his technology adoption decisions. Cattle supplementation and crossbreeding schemes illustrated this. Other aspects related to cattle turnover are also highlighted by this farmer such as pasture carrying capacity, stocking rate and predicted weight gain. Thus, technology that contributed to increase these aspects is appealing to farmer 14.

This farmer's strategies to increase cattle turnover are tuned into market conditions. For this reason, **actual and future beef prices** are criteria that farmer 14 monitored and made decisions from. Major negative changes in beef prices had impacts on the technology cost-benefit ratio and, consequently, on this farmer willingness to continue adoption. His rule of thumb is: when beef price falls dramatically, investments are put on hold and some technology discontinued. Related to this view is farmer 14's claim that **shortage of cash** may prevent him from technology adoption. He believed, for instance, the only reason to stop cattle supplementation is if he had no cash to afford it.

This view is particularly relevant to farmer 14 in the context that he is a very cautious borrower. He often borrowed money to finance investment capital to allow the farm growth but not often for working capital. He only borrows small amounts with attractive interest rates.

Another factor that prevented him from adoption is the lack of machinery. He did not produce cropping because he did not have the necessary machinery. In this particular case, other factors cited above might have also contributed for non-adoption, such as a lack of cash or attractive loans to purchase machinery, cropping knowledge and a pessimistic cost-benefit assessment on cropping production, considering its risk.

Farmer 15

Background

Farmer 15's background is related to farming as his father is a beef producer. In addition, he studied agronomy and worked for a fertiliser company for 17 years. He is 66 years old and had 26 years of experience as a beef producer. Beef cattle have been a secondary activity for all this time, since he had several different businesses. In his view, cattle production is like a savings account in case these businesses went wrong. Usually, he dedicated 20 percent of his time to farming and got 30 percent of his income from it. He is married, with his wife helping on the farm with the technical and financial controls. They have three adult children, none of which are involved with farming.

Farming system

In 2004, farmer 15 bought 92 ha and leased another 70 ha nearby, in a partnership with his son-in-law. Given his small farmland and his dream of having eight head per hectare, farmer 15 developed a project to intensify productivity by investing in pasture reform with agricultural terrace construction, soil fertilisation, grass replacement and establishment of water facilities and fences. His 145 hectares of rotational grazing system allowed him to carry 2.7 hd/ha (or 2 AU/ha) and finish 600 head annually. His farming system consisted of rearing and fattening heifers only, which he usually bought with 240 to 300 kg liveweight and sold with 390 kg liveweight and 24 to 36 months of age. During the rainy season, the entire herd are maintained on pasture only. During the dry season, however, rearing cattle are also supplied with protein-salt complex whereas finishing cattle (with 300 kg liveweight and over) are finished in open-air feedlots with silage and feed concentrate.

Farming management

Farmer 15 heavily relied on cattle weight to make decisions, particularly regarding pasture and supplementation management. He kept records of cattle weight gain (per group) and retrieved this information to calculate return on investment (e.g., when comparing two alternative supplementation schemes). Besides cattle weight, he also took into account beef and input prices in his calculations. Apart from planning, he also kept records for tax purposes and cash flow control. His wife is in charge of recording all receipts and sales on spreadsheets and provided him with monthly reports. However, he did not know the cost of production and believed such a sophisticated measurement is irrelevant in his decision context. Around 30 percent of farm operations are financed externally; the low interest rate and his risk-taking behaviour being the main motivation for borrowing money.

Farmer 15' main source of information is other people. He is very active and is constantly interacting with other farmers and consultants. He enjoyed going to field days and exchanging ideas and experiences with these people; particularly those experienced in fields he is deficient.

Technological profile

Overall technology adoption rate: 63%
Production technology adoption rate: 69%
Environmental technology adoption rate: 50%
Managerial technology adoption rate: 64%

Motivations and barriers for technology adoption

Farmer 15 had a moderate level of technology adoption across all types of technologies. His technological profile, however, suggested this farmer prioritised production and managerial matters. This is justified by his goal of earning twice as much he is getting from farming.

The first technological aspect that farmer 15 assessed, consciously or not, is technology **compatibility** with his system. He did not adopt technologies, or discontinued its adoption, if he figured that particular innovation is not suitable for his farm. Suitability is mainly seen in terms of environmental conditions, farm scale of production and number of employees. Once passed this criterion, other criteria are looked at.

Farmer 15's main motivation for technology adoption is **return on investment** as this farmer's major focus is on increasing revenue per hectare. His strategic decisions are all linked to this criterion. He decided to sell his bigger farm and lease a smaller one because in leasing he avoided fixed costs making his produce more profitable (e.g., less capital on land). Also, he decided to intensify production with high levels of fertilisation as this allowed him to increase beef turnover in higher proportion than its relative costs.

As he is permanently reassessing returns, he is tuned into market **relative prices** and is ready to change his farming system at any one time to respond to changes in market conditions. At the time of the interview, he was considering the possibility of no longer producing heifers and instead, working with steers only, because of the potential exports of beef from *Mato Grosso do Sul* State for European Union market. His price-related behaviour is also illustrated by: the fact that he first opted to produce heifers to get premium price; his decision to stop with animal individual identification when return on traced cattle is unclear; and, finish only *Nelore* cattle because market prices of store crossbred cattle is higher.

It followed from this, that high costs of implementation and maintenance often prevented him from technology adoption. This barrier is mainly related to this farmer's farm size, which limited his capacity of investment. Additionally, lack of experience and enthusiasm prevented him from on-farm diversification (e.g., forestry and cropping).

A usual strategy this farmer put in place is to **visit** and talk to other farmers about technologies. Once he identified potential benefits of a given technology, he **tested** it on a small scale on his farm to allow not only to check results but also to learn how to handle it before implementation on a larger scale. An appropriate technology, in his view, must improve weight gain while not damaging the environment. **Risk**, however, is not a major criterion for farmer 15's decision, as he admitted enjoying running some risks in order to grow.

Socially speaking, the major influence on his decisions is his nephew who is a consultant and with whom he often talked. His business partner, on the other hand, had little influence on decision-making, being mainly a beneficiary of the farm results.

Farmer 22

Background

This 31-year-old veterinarian had seven years of beef farming experience on his family farm. His mother is the farm owner and both, her and farmer 22, made their living out of farming. Farmer 22 is single and lived in town (105 km away), visiting the farm once a week.

History

Farmer 22's family had a long history in farming. In the late 1800's, his great-grandfather owned 40,000 hectares. After successive subdivisions of land, farmer 22's mother inherited 300 ha in 1985. Later, the family bought a 100 ha (contiguous to their farm) and another 400 ha farm nearby. Farmer 22's father established a low input system of cow/calf production. Concurrently, bits of land are leased for other farmers, some of whom are failing to pay the agreed lease price. As a consequence, the family struggled to reinvest in the farm. Farmer 22 took over the farm in 2001. The main changes he introduced are a mating season and practices to reduce overgrazing.

Farming system

The two farms ('A' and 'B') are integrated and run a complete cycle of beef production. The production system, however, is not stable since farmer 22 has been changing strategies to respond to changes in market conditions. Farm 'A' held a cow/calf production only whereas, in farm ‘B’, farmer 22 is discontinuing his cow/calf herd to focus on rearing and finishing cattle. Each farm had 400 ha, summing up 525 ha of pasture and 900 beef cattle. Calves produced in farm ‘A’ are sold at weaning, if they are male, or reared up to one year old, if they are female. At this age, farmer 22 selected heifers to replace breeding cows and stay in farm ‘A’ while the others are sent to farm ‘B’ to rear and finish. In 2007/2008 season, farmer 22 sold 60 weaners and 130 heifers with ages ranging from 30 to 36 months.

Farm management

Regarding the farm management, farmer 22 admitted he did not have a thorough control of the farm, running it instead on an intuitive basis. He claimed is not into administration tasks and described himself as a ‘field’ man. Also, the low qualification of staff prevented him from carrying such controls. The only records he kept are stock numbers and salt consumption. The same applied to finances: he kept receipts of a few items such as salt, wages and fuel. He made a spreadsheet that he seldom typed data in.

Technological profile

Overall technology adoption rate: 33%
Production technology adoption rate: 38%
Environmental technology adoption rate: 13%
Managerial technology adoption rate: 36%

Motivations and barriers for technology adoption

Farmer 22 is at the bottom of the group of farmers with moderate levels of technology adoption. This result reflected this farmer’s financial constraints over the past few years. Thus, he prioritised production technologies and managerial technologies (e.g., low-cost ones) over environmental ones.

Farmer 22 is profit-oriented and, as a result, is highly price-responsive. **Beef price** is this farmer’s main criterion for decisions on technology uptake. A low beef price stopped him from technology adoption while an increase in this price motivated him to uptake innovations. He mentioned several examples where this rule applied: he discontinued part of his cow/calf operation because store steers’ prices had fallen. At the time of the interview, though, farmer 22 is building up the cow/calf herd again as prices boosted the year before. His price-responsiveness is also valid for input prices, as he discontinued adoption when input prices increased or did not invest in technology if he judged it too expensive (e.g., pasture reform).

This farmer’s attachment to prices is related not only to his profit orientation but also to his financial constraints. In this sense, his **cash flow** position is a major boundary for decision-making. This is particularly relevant in the context that farmer 22 is not keen on loans. Any investment is only made if he had enough capital of his own.

Such a rule is a reflection of this farmer's **attitude to risk**, which influenced other decisions as well. He decided to carry on with beef farming because of its low risk and avoided cropping for the opposite reason. Technologies that involved high risk, therefore, are not appealing to farmer 22.

Technologies that are **difficult to handle** are also unappealing to farmer 22. His **staff's low qualification** and difficulties in dealing with demanding tasks are the main constraints to this type of technology. Another limitation is the fact that farmer 22 is not often on the farm to support employees' learning process and monitor their performance. In contrast, technologies are appealing when easily understood and handled as farmer 22's philosophy is to keep the farm simple and easy. This, among other factors, justified his decision of using protein-salt complex to feed cattle.

In order to keep informed about technology updates, farmer 22 browsed the internet and read journal articles and magazines. He also went to seminars and talked to other consultants. He **visited** other farms, particularly if he had no previous knowledge about a given technology. In this particular case, he also **tested** it on a small scale first. Otherwise, he implemented it immediately.

From a social standpoint, farmer 22's mother is the most influential person in this farmer's decision since she is the farm owner and he always listens to her opinions. However, farmer 22 claimed that she hardly disagreed with his decisions, as they held similar values.

Factor 4 – The Aspirant Top Farmer

Farmer 01

Background

Farmer 01 is 28 years old, single and had secondary education. His father bought the farm in 1983, when he retired after working for 45 years in slaughterhouses. Farmer 01 joined his dad as a farmer in 1997, at the age of 17. Farming is the family's only source of income.

History

When farmer 01's father started farming, he finished bulls with 8 to 9 years of age and 750 kg of liveweight under an extensive system. Gradually, the farm is intensified and became a very intensive rearing and fattening system. He used to have 5,000 head in his farm, but recently reduced this to 4,500 because the cost-benefit is more favourable.

Farming system

The farm had 3,465 hectares of which 3,000 are pasture. All paddocks are under rotational grazing, varying from 50 to 100 hectares. Millet (*Pennisetum glaucum*) silage and sugarcane are grown to feed cattle during the dry season, when grass availability and quality drop. In his farming system to date, store steers are bought at 8 to 10 months of age and sold to slaughterhouses at ages varying from 18 to 26 months. During the rainy season, store steers are maintained exclusively on pasture whereas during the dry season cattle are also provided with a protein-salt complex, resulting in an average daily weight gain of 630 g. Finishing cattle are provided with concentrate in open-air feedlots for about 90 days before slaughter, gaining an average of 1,250 g per day. The annual production is 3,600 head. Farmer 01 also had few milking cows to produce and share milk with the staff.

Farm management

Regarding the farm management, this farmer had a strong focus on cost control. He kept financial records and used this information to plan investments, particularly his loan demand. He also used these records to identify trouble areas that he should focus on to avoid wasting money. Moreover, this farmer kept technical records, as *per* ERAS/SISBOV requirement, including some animal performance indicators. Both financial and technical aspects are controlled on spreadsheets he developed.

Decisions, in general, are shared by farmer 01, his father and brother. Farmer 01's father is in charge of the finances and paperwork control while his brother responded to cattle commercialisation. Farmer 01, in turn, is the main decision-maker on technical issues, thus, on technology adoption decisions. In order to make qualified decisions, this farmer constantly sought agricultural information. His main source of information is the internet. Additionally, he read technical magazines and publications from EMBRAPA, went to seminars and visited many farms. He also enjoyed interacting informally with several people, including consultants, salesperson and other farmers. He tried to keep an open door strategy on his farm and attracted many visitors along the years. However, he is not involved with any formal group, such as associations, cooperatives or other organisations.

Technological profile

Overall technology adoption rate: 53%
Production technology adoption rate: 57%
Environmental technology adoption rate: 44%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

Farmer 01 had moderate levels of technology adoption for all technology clusters (i.e., production, environmental and managerial), hence, moderate level of adoption in general. Farmer 01's aim of intensifying beef production while keeping costs under control supported this profile of adoption, clearly focused on production and managerial technologies. Other specific socio-psychological aspects also contributed to such a result and are explored below.

The main criterion for decision-making on adoption is the potential **cost-benefit** of technology. This criterion is primarily assessed under a financial perspective, followed by a production standpoint. Before adoption, farmer 01 claimed he always estimated how much a particular technology costs (i.e., purchase price and maintenance costs) and what potential benefits it has (i.e., profit increase and/or cost reduction). He constantly referred to this aspect when discussing any technology.

Cost-benefit analysis not only influenced this farmer's adoption behaviour but also decisions on discontinuation. The main reason to discontinue technology is under-estimated cost or overestimated benefit. It follows from this, that technology is constantly reassessed and cost-benefit analysed by farmer 01. This led to another relevant decision criterion in this farmer's view: **technology reversibility**. This is the ability to quickly modify or discontinue technology if any condition becomes unfavourable (e.g., diet composition if grain price increases). In other words, farmer 01 is more willing to use technology he had flexibility with than technology he could not change once he decided to invest (e.g., central pivot).

Another relevant criterion for farmer 01 is risk control. He said he is more cautious than his father when making decisions and preferred to run **controlled risks**. A strategy this farmer often used to mitigate risks is to **test** any technology before implementing it on a larger scale. During the test, the innovation is compared with his current technology or practice in order to decide whether he should shift to the new system. When a technology is not feasible for small scale testing (e.g., electronic traceability system), he visited other farmers who are adopting to gather additional information.

Other criteria considered by farmer 01 when making adoption decisions are: installed capacity and requirement for additional investment on machinery, logistics (e.g., feed distribution), ease of use, availability of own capital or, alternatively, interest rate and other conditions to get a loan. One aspect he highlighted that prevented him from adoption is the **quality of the workforce**. If staff are not prepared to carry out a particular practice, or handle a technology, he gave up on technology adoption.

From a social standpoint, farmer 01's decision-making is often influenced by 'important others', particularly his father. Although farmer 01 had a high degree of autonomy, he discussed ideas with his father since this farmer acknowledged his father is very experienced and is still the legal farm owner. Other farmers and salesperson indirectly influenced farmer 01's decisions in providing him with agricultural information, ideas and criticism on innovations. Formal social groups (e.g., producers' associations) played no or little role on this farmer's adoption behaviour, however.

Farmer 03

Background

Farmer 03 is an agronomist with masters in cropping and 10 years of experience in farming. He is 41 years old, married and has three young children. His wife is also an agronomist and is involved with some small scale horticulture on the farm to distribute to a poor village nearby. Farmer 03 and his family lived in town and he visited the farm once a week. He had off-farm businesses, which provided him with 70 percent of his total income. Spirituality is a major aspect of this family's life.

History

In 1997, farmer 03's father sold a business and decided to invest in farming in *Mato Grosso do Sul* State, where farmer 03's mother also had a property. In 1999, his father bought this 1,543-hectare-farm and farmer 03 was hired to implement an ambitious beef cattle project. This project aimed at an innovative farming system, based on high stocking rates (3 to 4 AU/ha/year) and cattle age at slaughter ranging from 12 and 24 months. Five years later, they realised such a high stocking rate is causing pasture degradation and bringing uncertainties to the project's original returns on investment. A regional beef crisis in 2005 hit the farm badly and farmer 03 decided to sell part of the herd, keeping only the cow/calf herd. Since then, he has been slowly recovering from this crisis and rebuilding his capital.

Farming system

The farming system, which used to be based on high levels of supplementation and silage, became exclusively reliant on mineral mix and pasture. Rotational grazing is carried out on 1,200 ha, mostly sowed with *Brachiaria brizantha* cv. Marandu. He also had 9 ha of sugarcane to be used during the dry season. Unsuccessful attempts to recover pasture using cropping led him to give up on this.

Farmer 03's herd consisted of 700 breeding cows, 30 improved genetic bulls and 580 calves, on the average, totalling 1,310 head. Every breeding season, the bulls are tested for fertility and the breeding cows for pregnancy. He shifted from artificial insemination to natural mating because the later provided him with more calves as a result of higher pregnancy rates. The average weaning rate is 83 percent. He built up a good image among other farmers for producing heavy and high quality calves. Consequently, farmer 03 received 10 percent higher prices for his produce compared to the regional market.

Farm management

Regarding the farm management, farmer 03 is in charge of the strategic and tactical management whereas one staff member responded to the operational management. He had another four staff and established clear roles to enable them to work with minimum supervision, which is important for him since he is not at the farm every day. He developed technical and financial controls and used spreadsheets to analyse data, including budget and cash flow. All farm investments and running costs have been financed with own capital, often borrowed from his other businesses and repaid as soon as the farm capitalised. He considered getting loans when interest rates are low. The main limitation for this has been the limited credit available per farmer.

This farmer's philosophy is to be innovative and seek excellence. To pursue such a value, farmer 03 tried to keep up to date with innovations by reading rural and scientific magazines, visiting research centres (e.g., EMBRAPA, MS Foundation) and participating in seminars. Additionally, he adopted high technology and hired specialised consultants. However, after 'fighting for survival during the hard times', he learned he should rely more on his experience and intuition. His idea of being innovative in all aspects simultaneously is then reduced to particular aspects of production. As a result, private consultancy became restricted to a few areas (i.e., where farmer 03 had no expertise). He shifted from being a pioneer to being a follower, but still at the forefront of adoption, as he stated.

The farm's future, in his opinion, is uncertain. The property is his father's and, within his succession plan, farmer 03 will have to share the farm with his two siblings, who are not involved with farming. The lower return of the beef enterprise compared to returns on his other businesses made him wonder if he would keep farming for the years to come. Although he preferred to work with long term planning, at that stage he is constrained by external factors. For this reason, he has been working on short to medium term objectives, such as: (a) to rebuild the herd; (b) to increase the annual revenue; and (c) to establish a complete cycle system again.

Technological profile

Overall technology adoption rate: 49%
Production technology adoption rate: 43%
Environmental technology adoption rate: 50%
Managerial technology adoption rate: 60%

Motivations and barriers for technology adoption

At the time of the interview, farmer 03 had significantly decreased his level of technology adoption which impacted the adoption rates above. The main constraint for adoption, or reason for discontinuing technology, is **shortage of cash**. As a consequence, technology purchase price became a major driver of this farmer's decisions on whether to adopt, or continue adoption. For technologies/practices where this criterion did not apply, such as budgeting and cost control, adoption is constrained by farmer 03's perception on the gap between **knowledge required** and his actual knowledge, as well as the **cost**[23] of acquiring additional knowledge. Only after passing these constraints, other decision criteria are analysed.

Other criteria he considered when making adoption decisions are the technology ease of use, benefits/returns, quality of workforce and testability. In this farmer's view, technology must be **easy to use** and provide rapid and **clear results** (e.g., higher weaning rate). Unclear benefits prevented him from adoption. Another factor that discouraged adoption is the **quality of the workforce**: if technology is too advanced, adoption is constrained, delayed or discontinued, until he believed his employees are able to handle it. Ideally, a technology should also be **testable**. Farmer 03 liked to test innovations on a small scale before implementation. When not possible, he **visited other farmers** who are adopting.

Decisions on technology uptake used to be influenced by farmer 03's father, who is no longer involved with farming. Farmer 03 used to be an active member of the Rural Union and took part in experience exchange groups. These formal social networks used to play a more relevant role in farmer 03's decision-making process but he is not involved with these any more. His interactions with other farmers remained important, however, as a source of information and debate about technology advantages and disadvantages.

[23] Additional cost included not only expenditures with training course and books, but also time, energy and cost of failure.

Farmer 04

Background

Farmer 04 is married and has two adult children, none of whom are interested in farming. This farmer is 50 years old, with 10 years of farming experience. He had started, but had not completed, a degree in business administration. He managed, together with his wife, another business in town, where the couple lived. The farm represented 70 percent of his assets but provided him with 30 percent of his income, whereas for the other business it is the other way around. The farm is 47 km away from town and he visited it once a week.

History

In 1982, farmer 04's wife inherited this 250-hectare farm, which was immediately leased for cropping. In 1986, farmer 04 took over the farm, sowed pasture and started producing calves. In 2001, he shifted from cow/calf production to a rearing/fattening system, as the former is proving unviable for such a small farm. He invested heavily in infra-structure on the farm including electricity supply, fencing, well and troughs.

Farming system

This farmer's production consisted of rearing and fattening 500 heifers under a rotational grazing system on 230 ha of pasture. Within this production system, he bought weaners from 8 to 12 months of age, dewormed and weighed them. Growth and weight gain records are kept in order to support decisions on the herd management. When cattle reached 250 kg of liveweight, farmer 04 changed the diet to finish them at 300 kg of liveweight[24]. He finished 500 heifers annually, at ages varying from 20 to 24 months.

As a small land owner, he believed on-farm diversification is important. This is the reason he also had 80 sheep and 15 milking cows; the latter for cheese production. Cropping, however, is not among the option for diversification. Farmer 04 claimed the climate is unstable and the roads unpaved, making the production flow difficult. Additionally, he preferred beef production over cropping because he liked cattle and it is less demanding than cropping.

Farm management

He believed the farm is a business and needed to be managed in a professional way, 'looking beyond the gate'. He has been going to seminars on entrepreneurship because he claimed *"farmers are experts at the farm gate level but beyond the farm gate they are ignorant"*.

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[24] In Brazil, beef prices are established on the basis of 15 kg of carcass weight (equivalent to 30 kg of liveweight), the so-called *arroba* (notation: @). The liveweight-carcass conversion is based on an average of 50 percent carcass yield. In 2008, the average beef price for finished steers is R$60.00/@ (or NZ$47.14/@).

Farmer 04's tried to be as well organised and meticulous as possible. His managerial practices included technical and financial control. The technical control is limited to weight control, which is used to group heifers into homogenous groups. There is no individual identification and data is recorded on a paper diary on a cattle group basis. He had spreadsheets to control costs. In his system, beef cost is determined by expenditures on salt, mineral mix, vaccines, pasture lease (i.e., opportunity cost of his own pasture) and wages. He acknowledged, however, that he did not do this systematically.

Despite being passionate about farming, he claimed its revenue is not enough to make a living out of it, justifying why he had an off-farm business. Often, revenue is also not enough to reinvest in the farm. Thus, he borrowed money to invest in infra-structure (electricity, fence and water facilities) and would not mind doing it again if conditions are suitable.

Technological profile

Overall technology adoption rate: 48%
Production technology adoption rate: 38%
Environmental technology adoption rate: 78%
Managerial technology adoption rate: 36%

Motivations and barriers for technology adoption

In general, the adoption level of this farmer is 48 percent, grouping him with other innovative farmers who had intermediate levels of adoption. His main constraint for adoption is **cost**. He has been **experimenting** with different supplements in order to allow for cost reduction. In these trials, he often did not follow the recommendations strictly. When results are frustrating, he gave up on the technology even though he acknowledged that the chances are it is not a technological problem.

The **farm size** is another factor that prevented farmer 04 from adopting more advanced technologies. Also, technologies that required **high workloads** or **specialised workforce** could stop him from adoption. He claimed he wanted innovations that are **easy to use**, keeping the system simple since he had an off-farm business.

In contrast, **weight gain** is the main motivation for adoption decisions. Every strategy is measured against weight gain performance. If it resulted in weight gain, and depending on the cost, the technology appealed to him. Therefore, **cost-benefit** is another aspect he constantly analysed.

Other farmers and a friend, who is a consultant, are farmer 04's main sources of information on farming. Other social influences on adoption decisions are not noticed as this farmer barely commented on them.

Farmer 06

Background

Farmer 06 is 62 years old, retired, married and has two adult children. He had a tertiary education and is the owner/director of a business group. His wife and children also worked at this family's business. In 1998, he decided to go farming to make room for his kids to take the family business over. He believed if he stayed as director, he would never be able to know if his children are able to manage the business by themselves. Going farming is, then, a strategy farmer 06 put in place to prepare his succession plan.

Although he had neither family tradition nor experience in beef cattle, he is passionate about it and found farming rewarding and challenging. He claimed he used all the *"expertise and entrepreneurial skills"* he developed while managing the family business, in farming. He also claimed farming has been a motivation in his life and kept him active. He reported all his income came from farming and there had been no cash transfer between his businesses. He lived in town, though, and visited the farm every fortnight (230 km).

Farming system

Farmer 06 had 3 farms, totalling 3,681 ha. He had a complete cycle system with 2,758 beef cattle under rotational grazing. Some of the herd is purebred. The three farms operate in an integrated way. Farm 'A', where the interview occurred, is a cow/calf and fattening operation (1,567 ha of pasture and 2,448 head). Breeding cows are supplemented with protein-salt complex during the dry season and calves have access to creep-feeding. After weaning, heifers are reared at farm 'B' and store steers reared at farm 'C'; both are supplemented during the dry season with protein-salt complex. When they are close to finish, they are sent back to farm 'A'. The best heifers are selected to replace old or culled breeding cows whereas the remaining heifers and all steers are fattened in open-air feedlots. The diet in the feedlot consisted of sorghum silage and concentrate. All cattle are traced and the farmer is enrolled in ERAS/SISBOV.

Farm management

He believed the farm's success depends on how he managed three types of resources: physical, financial and human. He liked to discuss ideas with his employees as he believed they are the ones who understand farming. In this context, his consultants are particularly important as he admitted understanding very little about technical issues. Regarding physical and financial resource management, he put practices in place to control production, productivity and finances. His staff made notes of every occurrence (birth, death, vaccination) on a notepad and sent to the office to be typed into spreadsheets. Also, the office staff kept purchase and sales records. Eventually, when interest rates are low, he borrowed money. However, he is limited by the amount the government allowed him to borrow. Once a month, he is sent financial and production reports which he claimed to use for decision making.

About technology adoption, his philosophy is to be neither at the forefront nor within the late group of technology adopters as he believed both extremes involve high risk. Instead, he wanted to be above the average farmer. He adopted modern technology to improve productivity and because he liked challenges.

Technological profile

Overall technology adoption rate: 69%
Production technology adoption rate: 80%
Environmental technology adoption rate: 33%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

This farmer is among the group of high technology adopters, although he claimed, during the interview, he did not want to be an innovator. This result is pushed by his high adoption of managerial and production technologies: the latter is consistent with his aim of improving productivity and increasing cattle turnover. Environmental technologies, however, are clearly not a priority for this farmer.

Beside the aim of productivity improvement, this farmer is very much focused on reducing costs. Within this context, **input/technology purchase price** is a major criterion for decision making on whether or not to adopt technology. This criterion is usually analysed in the light of potential returns. The rationale for adoption, in general, is: **future beef prices** must overcompensate for investment on a given technology. In other words, the marginal revenue after technology adoption must cover all expenses incurred by technology implementation.

Another aspect that is part of this farmer's strategy to decide on technology adoption is the possibility of **testing it on a small scale**. At the time of the interview, farmer 06 was undertaking four 'experiments': he was testing sugarcane in the feedlot, artificial insemination at fixed time with a small group of cows, finishing females in feedlots rather than on pasture and is finishing bulls instead of steers (castrated). Presumably, the practices that succeed will be expanded.

Consultants are very important to this farmer's decision making process as he had no farming background. He sought qualified professionals to support the farm development in the same fashion he had professionals managing his business in town. His family, on the other hand, had no interest in farming and, therefore, had no involvement with farming decisions.

Farmer 09

Background

Farmer 09 is a biologist with a Masters in Animal Science and an MBA. He is 39 years old, married and has two young children. This farmer and his family lived in town and he visited the farm once a week. His involvement with farming started when he was young and used to spend holidays on his grandfather's farm. Professionally, though, he had 14 years of experience. His income came exclusively from farming, although he had voluntary off-farm activities as well.

History

His grandfather's farm has been in the family since 1872, initially producing only cash crops. It was handed over to farmer 09's mother in 1994. She decided to let her children manage the farm as she had no interest in farming and lived in Brazilian Southeast region. In 1995, farmer 09, with his siblings' consent, decided to take over the farm, since he is the only family member with farming knowledge to develop the business. The farm was turned into a company and his two siblings became shareholders. He became the farm manager and had autonomy to make decisions. However, strategic decisions went through discussions among the three shareholders once a year.

Farming system

When farmer 09 first started, part of the farm was leased for cropping production, but was gradually taken back. The remaining land carried an extensive beef system. Initially, farmer 09 prepared a long term planning project in an attempt to organise the production system and improve performance. From 1996 to 2006, investments on infra-structure and machinery were massive and he almost doubled the farm production. At that time, all revenue was reinvested in the farm, which went through intensive pasture reform with cropping. Cattle production responded promptly and beef performance increased significantly. The same happened with cropping.

Farmer 09 had two farms (4,106 ha in total) and is leasing a third one (1,100 ha). The latter had cow/calf production (812 breeding cows) whereas on his farms he carried 2,100 ha of cropping, 500 ha with rearing and fattening beef cattle and 300 ha of sugarcane. His aim is to reach 500 ha of sugarcane to become a regular supplier of the sugarcane industry that had just been installed nearby. He also had 4 ha with eucalyptus to supply wood to the local market in the future. Farmer 09 believed on-farm diversification is important because of the synergy among activities as well as the balance between riskier activities with less risky ones. The result, in his view, is a more sustainable system in the long run, both from production and financial standpoints.

This farmer's system is based on CCIS, where soybean harvest is followed by maize sowing, which, in turn, is followed by pasture establishment. Weaned calves (8 months of age) brought from the leased farm are reared under rotational grazing systems in 500 ha all year round. During the dry season, besides pasture, they are provided with protein-salt complex while in the rainy season they are supplied with energy-salt complex. When steers and heifers reached 20 to 21 months, in general, they are sent to open-air feedlots to be finished. During this period, the diet consisted of sugarcane bagasse (an industry by-product) and high levels of grains to ensure daily gains of at least 1.4 kg of liveweight. This farmer's annual production is 600 head out of a 2,000 cattle herd.

Farm management

The farm is enrolled in ERAS/SISBOV and thus had the entire herd traced. Traceability is an important management tool for this farmer. In his view, it allowed for controlling performance, which he used for decision making. He enjoyed making informed decisions, grounded in his own farming data. Thus, he kept technical records in spreadsheets that he developed for each farm activity.

The same principle of informed decision making is applied to the financial and economic areas. Over the last four years his focus has been on improving the business administration. His particular learning interests were in planning, budgeting and cost control and analysis. As a result, every investment is carefully planned, with different scenarios analysed. Once projects are implemented, he monitored performance and analysed margins and returns. He also analysed the business as a whole taking into account financial indicators such as solvency, net capital ratio, profitability and others. For this purpose, farmer 09 adapted a piece of accountancy software to use as a managerial tool and cost control.

Such a comprehensive level of information is a result of this farmer's personal attempt to manage the farm as a business and achieve excellence. Moreover, he believed he needed to put sound management practices in place in order to provide his siblings (i.e., shareholders) with transparent and accurate information regarding the farm performance. This performance, along with new projects, is discussed during the meetings with his siblings. Alternatively, if they needed some real time information about the farm, they could also access a website farmer 09 had recently launched.

With regards to financing farm operations, this farmer's policy is to reinvest 40 percent of profits back into the farm. Borrowed money is only considered an option when conditions for repayment are attractive (e.g., low interest rates). In this case, farmer 09 limited borrowings to a maximum of ten percent of the total assets or to no more than 30 percent of profits.

Another policy that is in place is human resource management based on performance. Within this policy every employee, including five consultants he occasionally hired, had additional earnings linked to results they delivered. Moreover, he offered scholarships for youngsters to study and work. He believed that a motivated team that understands their role in the production system is the most important factor for a good performance.

Farmer 09 not only encouraged his team to improve their skills and become more qualified, but also played a relevant role in leading this learning process within his business. He constantly sought to improve his knowledge taking training courses, participating in seminars and debates and visiting research centres and other farms. He also read scientific papers and specialised magazines, discussing research results with his consultants before technology implementation.

Technological profile

Overall technology adoption rate: 73%
Production technology adoption rate: 67%
Environmental technology adoption rate: 56%
Managerial technology adoption rate: 100%

Motivations and barriers for technology adoption

Farmer 09 presented high levels of technology adoption across all types of innovations, grouping him with other top innovators. Unlike any other farmer, farmer 09 adopted all managerial technologies included in this study. The fact that his siblings are his business partners led him to adopt the policy of running the farm with transparency and professionalism, therefore, justifying such an emphasis on sound management practices.

On a strategic level, farmer 09 is highly committed to long term sustainability. At the tactical and operational levels of decisions this meant that adoption of technology is considered within the overall farming context. In other words, technology is not only analysed on an individual basis but also, and more importantly, within the farming system. This is the case, for instance, of his feedlot. Although feedlot gross margins are small, in his farm context this practice not only optimised the use of available resources (e.g., staff, machinery and cropping residues) but also supported pasture recovery during the dry season (intangible benefit).

The first aspect, farmer 09 looked at when considering technology adoption, is its **compatibility** with his farming system. If he found technology is incompatible then there is no further speculation about adoption (i.e., elimination by aspect). An example is legume-grass mix: he believed it is incompatible with his farming system as he already ran culture rotation through cattle-cropping integrated system (CCIS).

In contrast, if the technology is compatible then other factors are then evaluated. **Risk** is one factor this farmer carefully assessed. Although he did not consider himself risk-averse, he is not willing to run too much risk either. This is the reason he diversified his produce portfolio to supply different markets while he decreased his cropping land. His experience showed him that crop production involved high levels of risk (e.g., climate, disease, market etc).

Cost-benefit is another factor this farmer analysed. Farmer 09's analysis of technology cost-benefit involved both financial and production aspects, including some **intangible impacts of adoption**. Specifically, he analysed the **cost of implementation, the return on investment** and whether it is **adding to his produce** (e.g., improving quality and/or productivity). Another aspect he also considered is the **logistics** of production, given his large scale operation: if technology increased demand for workforce and machinery, he discontinued its adoption. On the other hand, if technology improved logistics, this farmer is more willing to adopt it, and then other benefits are further evaluated.

When considering adoption, farmer 09 use to read and learn about the innovation he is interested in, often asking his consultants to prepare literature reviews for him. He also discussed the issue with other farmers and researchers. Occasionally, he visited EMBRAPA offices. Once farmer 09 decided on adoption, he **did not test innovation** on a small scale first. Instead, he adopted it as per research recommendation. If results are disappointing, he did not discontinue adoption either. He tried to learn more about it and hopefully overcome its problems. Technology is only discontinued if problems persisted.

One aspect that prevented technology adoption is the **quality of workforce**. Although he had policies in place to encourage staff self-development, often they are not qualified enough to work with high technology. To make this type of innovation viable and overcome this limitation he had to hire other professionals.

From a social perspective, this farmer is very active and frequently socialised with all sorts of people. He is member of several associations, cooperatives and had political roles as well. His social interactions with these people in general, and with his consultants and other farmers in particular, are relevant sources of information. When it comes to major decisions, however, his siblings are the most influential 'important others'.

Multiple Loaders

Farmer 19 (factors 1 and 4)

Background

This farmer is a 40-year-old veterinarian, with 20 years of professional experience as consultant and 15 as a beef producer. His income is entirely from his off-farm activity. He lived in town with his wife and their young daughter, visiting the farm once a week.

History

In 1993, farmer 19 and his father started leasing farms to produce beef cattle. Over these years they leased more than 50 different farms. The farm where the interview occurred was leased in 2003. Farmer 19, his brother and father decided to buy 250 ha of this farm and keep another 510 ha under lease contract. As soon as they got this particular farm, they invested heavily in infra-structure (corral, fencing and water facilities) and pasture reform.

Farming System

This 760 ha farm held two main activities: the production of young *Nelore* bulls (purebred) and rearing/finishing steers. On average, the total herd consisted of 800 cattle, being 50 percent of each type. Within the genetic herd, farmer 19 ran a complete cycle system with 220 breeding cows under artificial insemination. This herd is registered at ABCZ genealogy control. It is also under a genetic improvement programme that controls progeny and recommends best mating matches schemes for his herd. Annually, he produced 100 2-year-old bulls. The commercial herd consisted of rearing and finishing traced cattle, where male-only weaners are bought with 8 months of age and sold when three years old. His annual production of finished cattle is 400 head.

Both herds are maintained exclusively on pasture, which is established in 570 ha. Farmer 19 has a rotational grazing system in place that is flexible with regards to the grazing cycle: depending on weather conditions, and thus, paddocks situation, he moves cattle around. Supplementation is offered only in very special occasions: when bulls are close to sale in auctions, during severe droughts or when this farmer needed cattle to be finished by a due date. Alternatively, he produced maize silage and often leased more land during the dry season to reduce the grazing pressure on his farm.

Farm management

The overall farm management is shared by farmer 19 and his dad. His brother worked on another farm and did not participate in decisions. Son and father discussed issues before decisions are made, although this farmer admitted his suggestions usually prevailed as he had a strong technical basis. His father is in charge of the routine management and earned a wage to do so. The routine management included, but is not limited to, controlling several technical aspects of production such as: weight and weight gain, stock control (births, deaths, cattle purchases and sales) and sanitary practices. Farmer 19 also had financial controls, with economic reports provided on a monthly basis with an annual performance report. This report included margins, costs and assets position (e.g., debt levels), allowing him to compare actual and past performance while making decisions on future actions.

Besides using his own reports to make decisions, he learned about farming information in internships, seminars and field days. Additionally, as a consultant, he had opportunity to visit many farms and see technologies in use, discussing their results with other farmers.

Technological profile

Overall technology adoption rate: 71%
Production technology adoption rate: 70%
Environmental technology adoption rate: 63%
Managerial technology adoption rate: 82%

Motivations and barriers for technology adoption

Farmer 19 is among the group of farmers with high technology adoption levels. This is a reflection of his high level of adoption, in particular, of production and managerial technologies. This adoption pattern fits with this farmer's attempts to increase efficiency, improve land conditions, produce added value products and, thus, make his gross margin larger. In this context, a whole-system approach is carried out and different areas of farming are tackled simultaneously.

Farmer 19's aim of increasing production brought to light one of his criteria for decision-making: **production improvement**. Technologies that improved the production of meat per hectare in the commercial herd, or the number of weaners in the breeding herd, are highly appealing to this farmer. If negative impact is perceived on production however, technology is discontinued.

This farmer is market-responsive and, therefore, tuned into market conditions, including prices, farm policies, market regulations and commercialisation strategies. As a result, changes in input and beef prices had a great impact on his technology adoption behaviour as they affected his perception on **cost-benefit** ratio. Increase in **beef prices** is farmer 19's major motivation for adoption: he established traceability and EUREPGAP certification on his farm because he saw a potential increase in his produce prices. However, after the Foot-and-Mouth (FMD) outbreak, beef prices dropped severely and he stopped with the traceability system. EUREPGAP certification, in turn, was also discontinued but because of **market conditions** (i.e., *Mato Grosso do Sul* State was forbidden to export meat after FMD outbreak).

Additionally, input **purchase prices** and/or costs of technology implementation/maintenance are important for farmer 19's technology uptake. An example is sanitary practices, including all cattle prescriptions and vaccinations: this farmer claimed there is no point in dropping some sanitary practices as these represented around only two percent of his expenditures. On the other hand, he discontinued embryo transfer because its cost is too high. Not only the high cost, but also the **difficulty of handling** technology led farmer 19 to discontinue adoption.

Farmer 19 tried to control risks. This is the reason he spread his production among several slaughterhouses: in doing so, he believed he is protecting himself from slaughterhouse bankruptcy. His risk behaviour also determined his attitude towards technology adoption. He claimed he is more often a follower than a pioneer as he wanted to make sure technology is viable and recommended for his production system. Such a view led him to visit several farms and ran small scale trials before wide technology adoption in his farm.

This meant that, beside his father's influence on his decisions, other farmers played their role as well. This is particularly evident through his engagement and active participation in several beef producers associations, such as APYS, ABCZ, ANCP (National Association of Beef Producers and Researchers). Farmer 19 indicated these associations influenced his decision both formally and informally: formally by means of regulations he had to cope with as a member, and informally by exchanging farming information with other associated farmers.

Farmer 20 (factors 1 and 2)

Background

Farmer 20 is 72 years old and had 38 years of farming experience, of which 28 years are with beef cattle production. He has been farming since 1970 and did not intend to stop farming until he is physically unable to. He lived on the farm, had no off-farm income and is passionate about farming and its associated lifestyle. Farmer 20 had secondary education, is married and has three adult children. Although none of his children are directly involved with farming, they usually helped their father organising farm records when they occasionally visited him at the farm.

History

When farmer 20 first started farming, his main activity was cropping. Later on, he decided to diversify into cattle, which, at that time, was limited to just a few animals. The high risk associated with crop production led him to shift to exclusive beef production as he believed this was a much safer activity. His cattle production is settled in a 600-ha property he bought in 1994. Initially, this farm was in its natural form. Farmer 20 cleared part of the forest, leaving several ‘forest buffers’ along with the legal reserve and permanent preservation areas. He also invested in infra-structure such as housing, fence, water facilities (trough and pond) and feeders. The farm system has been improving since then.

Farming system

The farm had 400 ha with sown pastures, where his 800 cattle grazed. Grazing is under a rotational scheme. This scheme is not rigid, though, as he did not establish a fixed period for rest and grazing cycles. Instead, he managed paddocks according to his visual evaluation on forage availability. During the dry season, the entire herd is supplied with fresh sugarcane but no supplement. Since there is no supplementation, finishing cattle are maintained on high quality pasture (i.e., *Panicum maximum* cv. Mombaça) to ensure a proper fat layer.

This farmer ran a complete cycle of production with crossbred animals. Besides producing heifers to replace old cows, this farmer also bought breeding cows in the market as he found it more interesting from an economical standpoint. His breeding cows, usually *Nelore*, are naturally mated with either Marchigiana or *Brangus* bulls. The herd is on ERAS/SISBOV, thus is traced.

Farm management

The traceability system compelled this farmer to keep records of cattle handling. However, such records are not used for performance measurement. Neither are they used for decision-making. The same situation occurred with financial records: although he controlled his cash flow, it is not intended to support decisions or control the production costs. Instead, it is maintained for tax purposes only. Farmer 20 believed that to work out the cost of production is irrelevant and that if known, would make him give up farming.

Farmer 20 had no formal consultancy but often discussed ideas with friends who are consultants. If he had a problem that he could not handle by himself, then he hired these professionals. He also liked to discuss farming with other farmers, although he admitted it is not frequent as his farm is quite isolated. Most of the ideas he gained where from watching cropping-related television programmes as he no longer reads magazines.

technological profile

Overall technology adoption rate: 48%

Production technology adoption rate: 44%
Environmental technology adoption rate: 63%
Managerial technology adoption rate: 45%

Motivations and barriers for technology adoption

Farmer 20 had moderate adoption rates for all types of technologies, thus, a moderate adoption level in general. Environmentally related practices are this farmer's most adopted cluster of technology, which is consistent with his personal value: he wanted to conserve nature while producing beef.

Farmer 20 is fond of **environmentally friendly technologies** as he believed nature depletion results in production decrease in the long run. This is the reason he kept several natural areas as they were originally. Additionally, he planted fruit trees not only for his own consumption but also to provide the local fauna with feed.

Besides the environmental impact, farmer 20 also analysed the **compatibility** between technology and his farming system. He claimed there are several innovations available on the market, the fact being they are not all suitable for his farm. Once the adoption decision was made, he did not try it on a small scale, but instead implemented it widely.

The most decisive criterion for this farmer's technology adoption is the **cost-benefit**, with benefits necessarily prevailing over costs. His decision on implementing creep-feeding illustrated this. Although farmer 20 claimed the cost of running a creep-feeding system is high, he believed its return is even higher: breeding cows recover more rapidly, calves are heavier at weaning and their stress after weaning decreases.

Additionally, farmer 20 assessed the **risk** involved with innovations as he is risk-averse. For this reason he gave up on cropping and decided for cattle production. He believed this is safer than cropping. His risk-averseness behaviour also prevented him from borrowing money as he is afraid of bankruptcy. He is proud of being debt-free.

The **low quality of workforce** and the **workload** associated with some technology are two limiting factors for this farmer's technology adoption decision. The former because some technology required skilled staff and this farmer reported it has been difficult to attract and maintain good employees on his farm. The high workload has also become a constraint since this farmer is physically less active as he used to be, given his age. Instead, he wanted to keep the routine easy and run the farm smoothly. This is the main reason for choosing natural mating over artificial insemination: the latter incurs additional workload and care.

Farmer 20 claimed that the external environment also influenced the adoption of innovations on his farm. He believed the **government's lack of support** for farming affected his farm. He saw himself limited in his adoption capacity because he had no incentive or subsidy to increase production. He also argued that the government has not been providing rural areas with good infra-structure (e.g., roads) making farming more difficult.

This farmer liked to share ideas and discuss farming issues, although he made decisions on his own. The most 'important others' are his sons and son-in-law. Less frequently, he asked for friends' (who are consultants) and other farmers' opinions.

Farmer 21 (factors 1, 3 and 4)

Background

Farmer 21 is 62 years old, married and has two children, none of whom are involved with farming. He is an agronomist and had 29 years of experience, being a beef farmer for 24 years. He is a politician, which provided him with income. The farm revenue is all reinvested in the farm.

History

Coming from a family of agriculturalists, farmer 21 was an agriculturalist himself from 1972 to 1984, when he started beef production. He used to have two farms and his wife another two. After selling his farms, he took over his wife's farms where his current beef production system is established.

Farming system

The two farms work integrated: farm 'A' had 1,790 ha and carried out cow/calf production while farm 'B', where the interview occurred, had 302 ha with rearing and finishing cattle. Pasture land totalled 1,414 ha altogether, established with high productive grass under rotational grazing systems. This allowed for an average herd of 3,000 head and a stocking rate of 2.1 hd/ha. Besides pasture, he produced other forage to supply cattle with: sugarcane is offered fresh during the dry season to several animal categories, including breeding cows; maize and sorghum silage are supplied in feedlots, along with feed concentrate. Supplementation is used as a strategy to increase stocking rates and support cattle weight gain, resulting in a short cycle of production. Farmer 21 finished 750 head annually, with ages varying from 18 to 23 months, for crossbred animals, and from 23 to 30 months, for *Nelore* cattle. Within cow/calf herd, farmer 21 had artificial insemination with heat synchronisation: *Nelore* heifers for breeding herd replacement are inseminated with sexed semen (for female calves) whereas the remaining breeding cows are crossbred with Aberdeen Angus, Simmental and Hereford. Calves are on creep-feeding until weaning, when male calves are sent to farm 'B' to finish. All heifers remained on farm 'A' for either finishing or replacing breeding cows.

Farm management

Cattle are traced and the farm is enrolled in ERAS/SISBOV. Farmer 21 had an office in town with a secretary and an assistant to compute all technical and financial data and provide him with reports. Technical reports included cattle weight and weight gain, based on which supplementation schemes are established and breeding cows are culled. Farmer 21 also kept thorough financial records in order to understand his cash flow position. To maintain it positive, farmer 21 had a strategy of spreading sales along the year while paying his bills in no more than three months, depending on the volume of cash required. Formal economic analysis, including margins and cost of production, is not carried out.

Technological profile

Overall technology adoption rate: 68%
Production technology adoption rate: 88%
Environmental technology adoption rate: 44%
Managerial technology adoption rate: 45%

Motivations and barriers for technology adoption

Although farmer 21 had quite high technology adoption in general, his uptake across different clusters of technologies is uneven. Clearly, his focus on improving production led him to adopt technologies with direct impact on the farm technical performance. Environmental and managerial technologies, on the other hand, did not get much attention. He believed there is no need for detailed economic analysis as he is satisfied with his cash flow position.

It follows from this farmer's technological profile and his interview that the major criterion he sought is an increase in cattle **weight gain**. His commitment to shorten the cycle of production made this criterion a number-one priority. His concerns with economic viability added another criterion to his decision-making process: **cost-benefit** analysis. He always assessed costs of technology implementation and maintenance, on one hand, and potential returns, on the other hand. Farmer 21's supplementation strategy illustrated this: he supplemented weaners in creep-feeding because he wanted them to gain weight rapidly and wean earlier and heavier. In this way, he enabled cattle to be finished earlier as well. In shortening the production cycle, farmer 21 is able to sell more cattle over a given period of time, over-compensating the cost of supplementation.

Farmer 21 claimed he is at *"the forefront of technology adoption"* and every time something new came up and is better than what he is doing he tried to adopt. Before adoption, however, he discussed with consultants, with staff members and, sometimes, with his wife. He also visited other farms or research centres (EMBRAPA and MS Foundation) to check technology out before making his decision. The fact that he is a member of APYS and a couple of cooperatives provided him with some technical support that helped him to decide whether or not to adopt particular innovations. Once he believed cost-benefit is satisfactory, he **tested** it in small plots before implementing in a large scale.

One aspect that led this farmer to discontinue, or prevented him from, adoption is technology **incompatibility** with his production system.

Farmer 23 (factors 1 and 3)

Background

Farmer 23 is married and did not have children. He is a 36-year-old agronomist with a Masters in Animal Science. Professionally, this farmer had 14 years of farming experience, although he had been informally involved with the family farm since he was a youngster. After graduation, he started a consultancy business but, as it became demanding, he could not manage this and the farm simultaneously and gave up on his business. At the time of the interview, farmer 23 is making his income exclusively out of farming.

History

Farmer 23's family worked with beef cattle as a secondary activity. His father bought a farm in 1985 and a second one, 30 km away, in 1993. When the farming system was first established it consisted of finishing cattle only. In 1994, when farmer 23 joined his father in the farm, the production system changed to a complete cycle and a crossbreeding programme was established. They also invested in infra-structure, including fencing, paddocks sub-divisions and corridors, to improve cattle handling. Later, farmer 23 took over the farm as his father is getting older and less involved with farming.

Farming system

Within this farmer's production system, both farms are integrated: farm 'A' held the cow/calf phase and farm 'B', the rearing and finishing phases. In farm 'A', *Nelore* cows are mated with

Brangus bulls within a 4-month mating season, achieving an average birth rate of 89%. Calves are on creep-feeding and receive a treatment (Zinc-based) to reduce stress at weaning. Thereafter, they are all sent to farm ‘B’ to rear and finish. In total, these two farms had 2,650 ha, of which, 2,100 ha is sowed pasture. A herd of 2,700 head (650 breeding cows) are grazed all year round under a continuous grazing system, with alternation of paddocks. Since his farm had poor soils and most pastureland was established more than 15 years ago, he has been reforming critical paddocks every year. During the dry season, the entire herd, except breeding cows, are supplied with protein-salt complex. Cattle are finished under a semi-intensive system, with supplementation on pasture during both the dry and the rainy seasons. This farmer’s annual production is 650 head at ages between 24 and 30 months.

Farm management

The herd is traced and the farm enrolled in ERAS/SISBOV. To comply with ERAS requirements, he kept some basic technical records. After taking a training course in farm management, he decided to implement more rigorous control, not only of technical aspects, but also of financial ones. In his view, it is important to control finances and know his cash flow in order to better plan his investments. For this purpose, he bought a piece of software to organise expenditures, sales and investments into accounts, allowing him to work out total costs of production. He also improved the spreadsheets he developed to record technical performance.

Besides this farmer’s high level of formal education in farm-related subjects, farmer 23 kept up to date with agricultural news through the internet and newspaper. He also went to several seminars and training courses. Another way of keeping informed is talking to researcher and to other farmers, particularly those affiliated in APYS.

Technological profile

Overall technology adoption rate: 59%
Production technology adoption rate: 60%
Environmental technology adoption rate: 38%
Managerial technology adoption rate: 73%

Motivations and barriers for technology adoption

Farmer 23 is among the group of intermediate level of technology adoption. Managerial technologies are the most adopted cluster by this farmer, who wanted to ensure his profits by putting in place mechanisms to control and understand the farm’s financial health. To a less extent, production and environmental technologies also got this farmer’s attention, since he is committed to improve the farm and ensure profits, subject to nature preservation.

When considering technology adoption, farmer 23 analysed the **cost of implementation** beforehand. Depending on his perception of whether technology is cheap or expensive, his willingness to adopt increased or decreased respectively. He did not adopt fixed time artificial insemination (FTAI) because he believed it was expensive, although he acknowledged its benefits.

Technology benefits, particularly from an economic standpoint, motivated farmer 23's adoption behaviour. He maintained that he did not *"mind investing if it ensures returns"*. Another motivation for adoption is technology **ease of use**. Difficulty of using technology, however, did not discourage this farmer if he perceived potential returns. This is the case of anti-stress treatment of weaners. He claimed it is cheap, although it is *"hard work"*.

His **previous knowledge** regarding particular technologies supported his adoption decision as he felt more comfortable and secure. On the other hand, the lack of knowledge made him insecure about investments and sometimes prevented him from adoption. This is the reason he has been wondering whether or not he should opt for on-farm diversification. Once he acquired the knowledge he 'needed', technology adoption is facilitated. An example is the recent establishment of a cost control system as a result of his participation in a management training course. Another way he learned about technologies is **visiting** other farms, but not through experimentation on his own farm.

This need for feeling secure in his steps is related to this farmer's **attitude towards risk**. He claimed he is cautious when making-decisions and tried to be as wise as possible in order to minimise such risks. Although he did not like risks, he argued that he tried to be up to date with technology and at the forefront of adoption.

Quality of workforce is one factor he emphasised that is a major limitation for technology uptake.

During the decision-making process on technology adoption, farmer 23 not only considered all the above aspects, but also his father's opinion. Although farmer 23 had autonomy to make decisions, he liked to discuss ideas with his father because he is experienced and is the primary beneficiary of the farm results.

Farmer 24 (factors 1 and 4)

Background

Farmer 24 is 40 years old, married and has two young children. He is an agronomist with a Masters in Animal Science. He started farming in 1991 at his family's farm and developed a passion for farming. He had no off-farm income, although he worked once a week for a beef producers association.

History

The farm where the interview took place has been in the farmer 24's family for three generations. When his mother inherited her share of the farm, her husband took over, even though he had no farming background. In 1991, after farmer 24 completed his Agronomy degree, he started helping his father with the farm management. Five years ago, farmer 24 took the farm over and started changing the farm profile. The major change he introduced was the shift from continuous to rotational grazing. He also discontinued the cow/calf herd, focusing on rearing and finishing stages only.

Farming system

Diversification is very important to farmer 24. His production system included forestry, embryo transfer with sales of recipient cows, rearing and finishing cattle and, more recently, a top genetics herd. He also had a small sheep flock, but that is only for his own family's consumption. From this 3,300-ha-farm, 523 ha are dedicated to forestry; 450 ha in partnership with a charcoal company and 73 ha on his own. This partnership is providing almost 11 percent of his total annual revenue. Within the beef enterprise, 2,250 ha are pasture under rotational grazing, holding around 3,000 cattle all year round. Some paddocks are established under high density of native trees (Figure G.5.a) whereas others had grass-legume mix (Figure G.5.b). Around 350 heifers are used for this farmer's embryo transfer programme. Within this programme, breeders collected embryos (from their donor cows) which are transferred to farmer 24's recipient cows. Once these are pregnant, they are sold back to the breeders. Alternatively, farmer 24 offered top *Guzerá* breeders the opportunity of sharing the progeny instead of buying the recipient cows. With this strategy, farmer 24 is building up his own elite herd. Regarding his commercial beef herd, farmer 24 aimed to add value to his produce and, thus, get a premium price for it. For this reason, he mostly reared and finished heifers, which are sold under a market alliance agreement. He also reared and finished steers in order to diversify his portfolio. The annual production consisted of 530 finished cattle with average ages of 24 months for heifers and 30 months for steers. Only 20 percent of production is finished on feedlot, with the remaining being finished on pasture only or on pasture with protein-salt complex, if during the dry season.

Farm management

Farmer 24 emphasised he is well organised and wanted to be aware of the farm's actual performance. He believed the only way he could do that is by controlling farming aspects, since he was raised in a town and claimed he did not have the natural intuition rural people have. In this context, farmer 24 put several technical and financial controls in practice. Cattle are individually identified, with individual weights recorded in a notebook (Figure A.5c) and used for decision-making on cattle grouping. Most cattle handling, such as vaccination and deworming, are established on a group basis, however. All data are transferred to spreadsheets for further analysis (i.e., performance and stock control). Farmer 24 also had spreadsheets to keep records of purchases, sales and cash flow. Additionally, he worked out indicators such as 'cost' per head and 'cost' per hectare.

(a) (b) (c)

Figure G. 4 Pasture within remaining forest (a), grass and legume mix (b) and notebook with cattle weight records (c)

This farmer's main sources of information are books and publications as well as the internet; the latter mainly for price and market conditions. He stated that he used to attend more seminars and training courses but recently has been relying more on exchanging experience and sharing ideas with other farmers.

Technological profile

Overall technology adoption rate: 65%
Production technology adoption rate: 64%
Environmental technology adoption rate: 78%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

In general, farmer 24 had an intermediate level of technology adoption. Such a result is consistent with this farmer's commitment to be *"the best farmer he could be"*. In this context, farmer 24 sought to improve the technical aspects of production, while respecting nature and carrying out sound managerial practices.

Technology adoption is only considered if farmer 24 believed he needed it. This means that if he is **satisfied with a current practice**, he did not search for other alternatives even though he suspected these are better. This process is often intuitive (unconsciously) as farmer 24 only thought about an explanation for non-adoption when directly asked. An example is pasture non-fertilisation: he is satisfied with the stocking rate and with the fact there is no pasture degradation, therefore, there is no apparent reason to fertilise pasture.

While non-adoption behaviour is sometimes unconscious, adoption behaviour is always purposeful. Farmer 24's main criterion for adoption is **return on investment**. He started forestry and embryo transfer because he envisaged higher returns with these than with beef. For the same reason, he discontinued cow/calf production: he predicted calf price is going to fall and so are its margins.

Despite high returns, technology is not adopted if it did not fit his **cash flow**. Having enough cash is a limitation not only for technology implementation but also for its continuation. This cautious approach is a reflection of farmer 24's philosophy of taking **controlled risks**. He described himself as *"sensible when making decisions"*, as he tried to work out the 'pros' and 'cons' of technology. Although he claimed he did take risks, he often preferred smaller margins, but safer ones, than greater margins associated with high-risk innovations. Consistent with his attitude towards risk is his strategy of testing technology on a small scale before wider implementation.

Difficulty on handling technology, in general, did not discourage farmer 24 to adopt it if he believed returns are guaranteed. However, the fact that staff and logistics are constraints to production on his farm, he often had to adapt technology to his conditions. He established, for instance, one week grazing in each paddock to make it easier for staff to remember which day to move cattle, even though he argued this is not the ideal for grass development.

Market conditions represent a great influence in this farmer's adoption and non-adoption behaviour. Farmer 24 is tuned into agricultural markets and kept open-minded when market opportunities arose. This is the case of forestry, embryo transfer and, more recently, the elite herd. His affiliation to APYS is another example.

In addition to this farmer's own perceptions on technology, other people and circumstances are influential on his technology uptake behaviour. His father is certainly the most prominent influence. Since farmer 24's parents are the main farm beneficiaries, farmer 24 discussed ideas with and reported results to his father, often listening to his advice. Being a member of APYS is another impacting factor on his technology adoption decisions. Firstly, to cope with the Association requirements he had to introduce some changes in his production system, and secondly, because being an active member of APYS gave him the opportunity not only to share his concerns as an individual farmer, but also to engage in discussions on challenges facing the beef sector as a whole.

Farmer 25 (factors 2, 3 and 4)

Background

Farmer 25 is 47 years old, single, had no children and is passionate about beef cattle. He owned another business in town, from which all his income came from. He lived in town and visited this farm twice a week. He also owned another two farms, which are 85 and 165 km from his home that he visited twice and once a month, respectively. He claimed his income did not come from farming so it did not justify spending too much money and time on the farm.

History

Between the years of 1979 and 1986, farmer 25's father bought six farms as part of his succession plan: leave one farm for each of his six children. Farmer 25 had no previous farming experience when he took over the farms in 2002. He claimed, though, that with his entrepreneurial skills, he intensified the system and boosted the stocking rate. He improved farm infra-structure, investing on fencing, pasture subdivisions and water facilities (Figure G.6.a).

Farming system

His three farms work in an integrated system, totalling 1,300 ha and 2,000 head. The cow/calf production occurred in farm 'A', where he crossbred *Nelore* cows with Angus or Simmental bulls (artificial insemination) to produce recipient cows for embryonic transfer. He also had some purebred *Nelore* bulls to produce heifers to replace part of his breeding cows. Cows for embryonic transfer are sent to farm 'B' where they are reared, had the embryo transfer and are sold to breeder farmers. Those that are not pregnant are fattened and sold under APYS programme, getting a premium price. All store steers produced in farm 'A' are sent to farm 'C' to rear and finish at ages ranging from 24 to 28 months. The herd is all identified but, apart from finished steers that focus on export market, the remainder are not under a traceability system. He kept technical (birth, death, vaccination) and financial (expenditures and revenues) records on spreadsheets he developed.

The farm where the interview occurred ('B') had 350 heifers and 270 ha, of which 200 ha are sown pastures established 20 years ago. He had rotational grazing of *Brachiaria decumbens* grass and his pasture management is based on grazing control to avoid overgrazing and, therefore, pasture degradation (Figure G.6.b). During the dry season, he also supplied cattle with sugarcane. The same grazing system applied to farms ‘B’ and ‘C’ and is being established in farm ‘A’. In farm ‘C’, where cattle are finished, they are fed for 45 to 60 days prior to slaughter in half-barrel feeders (Figure G.6.c). During the rainy season cattle are provided with protein-salt complex, whereas concentrate is supplied during the dry season. Within this scheme, farmer 25 is able to finish cattle all year round, usually selling between 20 and 30 animals monthly.

(a) (b) (c)

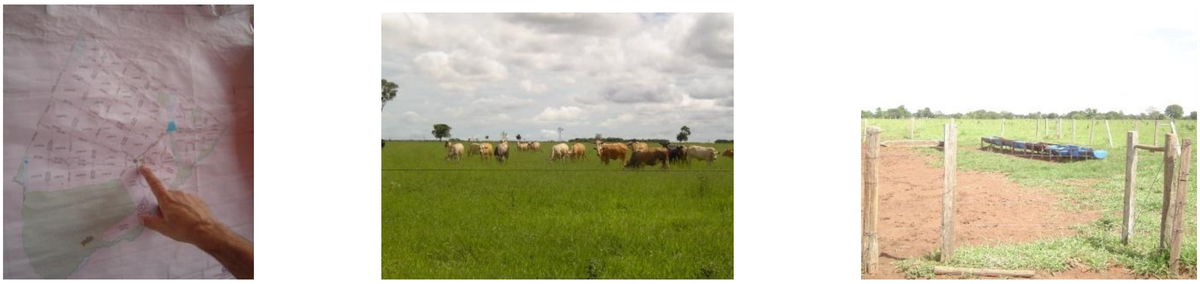

Figure G. 5 Map with farm paddocks (a), pasture and herd (b) and half-barrel feeder (c)

Farm management

He saw himself as an entrepreneur and aimed at increasing the cattle turnover. He borrowed money to invest in and organise his farms but did not want any more loans at current interest rates (6 to 8% a year). At the time of the interview, farmer 25 claimed the farm is not in debt. He decided to reinvest all farming revenue back on his farms. This, along with past external funding, has allowed him to increase the herd from 400 to 2,000 head in total and finish cattle earlier. The average age at slaughter dropped from 42 to 28 months.

Technological profile

Overall technology adoption rate: 60%
Production technology adoption rate: 63%
Environmental technology adoption rate: 63%
Managerial technology adoption rate: 55%

Motivations and barriers for technology adoption

In general, farmer 25 had moderate levels of adoption across all types of technologies. This meant he sought to run the farm balancing all business areas.

Farmer 25 objective of increasing the production turnover led him to seek this aspect in any technology whose adoption is being considered. In his view, **turnover** is more important to the financial success than cattle final weight. In other words, he preferred to slaughter lighter and younger steers, than heavier and older cattle. This criterion led him to adopt, for instance, crossbreeding, rotational grazing and supplementation.

Cash availability is one factor that prevented him from adoption, particularly if the technology/practice under analysis is not essential to beef production. It became a major constraint recently as this farmer decided not to borrow external money to finance the farm. Farmer 25 also stopped considering technology adoption when **benefits and rules/laws** involving that piece of technology are **unclear**. An example is the traceability system, which he kept under a minimum level as he claimed the government keeps changing the rules.

Farmer 25's has a rich network of farmers and knowledgeable people (cattle-related) with whom he gained ideas from. Usually, when he found out about an innovation, he **visited other farms** to check it and discuss results with his friends. If he found technology relevant for his farm and could afford it, he would analyse its **return**. If return is considered attractive he would decide for adoption.

However, he would immediately discontinue technology adoption if he had a **bad experience/result** (i.e., technology did not meet the farmer's expectations). Part of this bad experience, he acknowledged, could be related to **unclear recommendations for technology** (i.e., which situation farmers should avoid when using the technology). Often, he did not know how to explain why the technology failed but one experience is enough to keep him away from it.

Appendix H

List of statements and associated scores

H. 1 Normalised Z-scores of the complete array of statements for all factors

No.	Statement	Factors 1	2	3	4
1.	My goal is to work at the farm capacity to avoid land invasion	-1.17	1.18	0.21	-1.70
2.	Borrowings should be restricted to a low percentage of the value of assets	0.40	-0.68	0.19	-0.41
3.	There are times when I take the risk in order to succeed	0.45	0.00	-0.17	0.69
4.	A good farm manager has control over his/her farm and is not at the mercy of outside forces	0.35	-0.19	0.42	0.51
5.	My objective is to adopt new technology as much as possible	1.30	-1.11	0.57	1.26
6.	I always wait for other farmers to adopt new technologies before I do it myself	-0.59	-0.37	-0.70	-0.91
7.	I want to achieve the maximum profit feasible	0.00	-1.05	2.67	0.79
8.	The benefit from the security and liquidity of cattle ownership is important to me	1.16	0.50	1.11	0.53
9.	My objective is to increase the crop production	0.20	-1.61	-0.65	-0.07
10.	My goal is to run the farm as a business, with clear goals, and close attention to my cash flow position	2.22	1.36	1.45	1.58
11.	The technical performance is more important to the business success than the financial control and planning	-1.17	-1.80	0.98	-0.98
12.	I want to diversify my assets and invest in off-farm activities	-0.48	-0.93	-0.97	0.19
13.	My goal is to have the best quality of livestock and pasture possible – good husbandry is the key to business success	1.23	1.36	1.49	0.63
14.	I value my staff – they are fundamental for the quality of my production	1.72	0.31	1.24	0.93
15.	My priority is to improve animal welfare	0.64	1.55	-0.14	0.04
16.	I want to maximize the beef production in my farm	0.81	-0.87	1.38	1.94
17.	My goal is to improve pasture productivity and animal performance	1.27	0.87	1.08	0.72
18.	I do not intend to expand the business	-1.06	0.43	-0.48	-1.77
19.	My objective is to hand over the farm to the next generation in better conditions than when I got it	1.85	1.30	-0.58	-0.30
20.	The diversification of activities is not important to my farm	-1.16	-1.61	-0.27	-1.31
21.	I am a beef farmer because of the freedom of being my own boss	-1.26	0.93	-0.49	-0.58
22.	I try to make decisions on my own – I like things my way	-1.69	1.42	-0.96	-0.84
23.	An important goal to me is to have enough money for a comfortable retirement	-0.39	-0.25	1.81	-0.69
24.	I intend to have a higher withdrawal to live comfortably in the present	-0.45	-0.25	0.22	-0.05
25.	My objective is to reduce my workload and improve my quality of life	-0.56	-0.25	1.06	-0.69
26.	My goal is to have well defined roles and activities so that the farm runs smoothly	1.10	-0.43	0.35	0.68
27.	I try to control the sales of my production because I want to ensure I receive the best return possible for my products	0.60	1.11	1.37	1.09
28.	I do not have control over input and output prices; so I have to accept what the market imposes and there is nothing I can do	-1.15	-0.87	-1.08	-0.49

Appendix H (continued)

No.	Statement	Factors 1	2	3	4
29.	I want to have my farm recognized for producing high quality meat	0.71	0.87	0.44	1.77
30.	I avoid having debts – to have debts means poor administration, in my opinion	-0.49	-0.06	-0.48	-1.21
31.	I intend to encourage the next generation to do something else rather than farming	-1.36	-0.31	-1.21	-0.70
32.	I farm to follow the family tradition	-1.77	0.68	-1.51	-1.26
33.	My aim is to encourage our children to study and then let them decide if they want to go farming	1.65	-0.93	0.59	0.07
34.	My goal is to share farm work and farm decisions with my spouse	0.09	-0.19	0.73	-0.14
35.	To belong to the rural community is a satisfaction for me	-0.19	0.00	-0.63	0.32
36.	It is important to me to be recognised as a modern farmer	-0.46	-0.50	-1.43	1.27
37.	Some people put too much emphasis on the business end of farming; for me, it is a lifestyle as much as a business	0.00	0.43	-1.00	-0.39
38.	Business goals must take priority over household needs	-0.54	-1.80	-0.73	-0.86
39.	For me it is important not to allow the farm rule my life	-0.38	-0.25	-1.16	-0.23
40.	One virtue of farming is that you can have your family working alongside you	-0.23	-0.25	-1.62	-0.99
41.	Nature conservation is important and I value it as much as my income goals	0.89	2.23	0.16	1.22
42.	The good farmer does not exaggerate: moderate yields, modest improvements and old equipment suit me fine	-0.53	0.25	-0.21	-0.07
43.	There is no compatibility between beef cattle production and nature conservation: to improve one you need to disturb the other	-1.47	-1.98	-1.92	-1.94
44.	I want to enhance the landscape and have a beautiful farm	-0.43	-0.43	-0.24	0.52
45.	I really appreciate the outdoor life, close to nature and with animals around	0.54	1.61	-0.16	0.26
46.	My goal is to be the best farmer I can be	-0.18	0.25	-0.46	1.75
47.	I like innovating because new challenges inspire me	0.45	1.05	0.47	1.48
48.	I want to maintain some involvement in the farm, even after retirement	0.73	-0.19	0.05	-0.38
49.	I want to rest and enjoy retirement – it’s time for kids to take over the family farm	-1.22	-0.56	-0.78	-1.29

Appendix I

Rates of adoption of technologies by individual farmers and per factor

	Factor 01									Factor 02		Factor 03				Factor 04					Multiple Loaders						
Technology	**F05**	**F07**	**F08**	**F10**	**F11**	**F13**	**F17**	**F18**	**F26**	**F02**	**F16**	**F12**	**F14**	**F15**	**F22**	**F01**	**F03**	**F04**	**F06**	**F09**	**F19**	**F20**	**F21**	**F23**	**F24**	**F25**	**Adoption rate (%)**
Artificial insemination	1	-	0	-	0	1	1	1	0	1	-	1	1	-	0	-	0	-	1	1	1	0	1	0	-	1	**63**
Genetic Improved Bulls	1	-	1	-	1	1	1	0	1	1	-	0	1	-	1	-	0	-	1	1	-	0	1	1	-	1	**78**
Cross-breeding	0	-	0	-	1	1	1	1	0	1	-	1	1	-	0	-	0	-	1	0	-	1	1	1	-	1	**67**
Embryo transfer	1	-	0	-	0	0	0	0	0	0	-	0	0	-	0	-	0	-	0	0	0	0	0	0	-	1	**11**
Breeding season	1	-	0	-	1	1	1	1	1	1	-	1	1	-	1	-	1	-	1	1	1	1	1	1	-	1	**95**
Bull fertility test	1	-	0	-	-	1	1	1	1	0	-	1	1	-	1	-	1	-	1	1	1	1	1	1	-	1	**89**
Pregnancy test	1	-	0	-	1	1	1	1	1	1	-	1	1	-	1	-	1	-	1	1	1	0	1	1	-	1	**89**
Care of newborn calves	1	-	1	-	1	1	1	1	1	1	-	1	1	-	1	-	1	-	1	1	1	1	1	1	-	1	**100**
Creep feeding	1	-	1	-	0	1	0	1	0	0	-	1	0	-	0	-	0	-	1	0	0	0	1	1	-	1	**47**
Early weaning	0	-	0	-	0	0	0	0	0	0	-	0	0	-	0	-	0	-	0	0	0	0	1	0	-	0	**5**
Castration	1	-	1	-	0	1	1	1	-	1	1	1	1	-	-	0	-	-	1	0	1	1	1	1	1	1	**84**
Cattle supplementation	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	**81**
Feedlot for finishing cattle	1	0	0	0	1	1	1	1	-	0	0	0	1	1	0	1	-	0	1	1	0	0	1	0	1	1	**54**
Certified pasture seed	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	**88**
Pasture maintenance	1	-	0	-	1	-	0	1	1	0	0	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	**48**
Pasture recovery	1	-	0	-	-	-	1	1	1	1	0	1	1	0	0	0	0	0	1	1	1	0	-	1	0	-	**55**
Pasture diversification	1	0	0	0	1	1	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	1	1	0	0	0	**42**
Silage and/or hay	1	0	0	0	1	1	1	1	0	0	0	0	1	1	0	1	0	0	1	0	1	0	1	0	0	0	**42**
Grass and legumes mix	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	**31**
Capineira	1	0	1	1	0	0	1	1	0	0	0	1	0	1	0	1	1	0	1	1	0	1	1	0	1	1	**58**
Deferred grazing	0	-	0	-	-	1	1	0	0	1	0	1	0	1	0	0	0	0	0	-	1	1	0	1	0	0	**36**

Appendix I (continued)

Technology	Factor 01									Factor 02		Factor 03				Factor 04					Multiple Loaders						Adoption rate (%)
	F05	**F07**	**F08**	**F10**	**F11**	**F13**	**F17**	**F18**	**F26**	**F02**	**F16**	**F12**	**F14**	**F15**	**F22**	**F01**	**F03**	**F04**	**F06**	**F09**	**F19**	**F20**	**F21**	**F23**	**F24**	**F25**	
Rotational grazing	1	1	0	1	-	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	1	1	**76**
Strategic control of worms	1	0	0	1	0	1	1	1	1	1	0	0	1	0	1	0	1	1	1	1	1	0	1	0	1	0	**62**
Culling on reproductive performance	1	-	1	-	1	1	1	1	1	1	-	0	1	-	1	-	1	-	1	1	1	0	1	1	-	1	**89**
Soil testing	1	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	**81**
Expanded protection of headspring	1	0	0	0	0	-	0	0	0	1	0	0	0	-	0	0	1	1	0	0	0	0	0	0	1	1	**25**
Private reserve of the natural patrimony	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**8**
Agricultural terrace	1	0	0	1	0	1	1	1	0	1	0	1	1	1	0	1	1	1	0	1	0	1	1	1	1	0	**65**
Other soil conservation practices	1	1	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0	0	1	1	**54**
Water management and facilities	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	**92**
Manure management	1	1	-	-	0	0	-	-	-	1	-	-	0	0	-	0	-	1	0	0	-	-	0	-	1	-	**38**
Heavy-use area protection	0	0	0	0	0	1	0	0	1	-	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**12**
Tree planting	1	0	0	0	1	1	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	1	1	0	1	1	**69**
Fire **not** used to manage pasture	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**100**
Animal identification	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	**88**
Technical records (control)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**100**
Formal investment planning	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	**23**
Financial control	0	1	0	1	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	**38**
Managerial software	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	**81**
Scale to weigh cattle	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**92**
Sanitary control	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	**81**
Staff evaluation/reward	1	0	0	1	0	0	1	1	1	1	0	1	1	0	0	0	0	0	1	1	1	0	0	1	0	0	**46**
Futures trading	1	0	0	0	0	0	0	0	-	0	0	0	0	1	0	1	-	0	0	1	0	0	0	0	0	0	**17**
Participant on market alliance	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	**77**
Analysis of total production costs	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	**15**
Adoption rate (%)	**82**	**47**	**27**	**62**	**61**	**76**	**75**	**77**	**59**	**75**	**21**	**57**	**60**	**63**	**33**	**53**	**49**	**48**	**69**	**73**	**71**	**48**	**68**	**59**	**65**	**60**	

Appendix J

Statistic analysis on adoption rates

T-test probabilities for the paired comparisons

Paired comparisons	Types of innovative beef farmers*				
	PF (n=9)	CE (n=2)	PM (n=4)	ATF (n=5)	ML (n=6)
Production/Environmental	.007**	.176	.039*	.743	.504
Production/Managerial	.842	.398	.209	.376	.532
Environmental/Managerial	.092	.751	.042*	.459	.899

* Significant at 5%; ** Significant at 1%

F-test probabilities for a comparison of farmer types by technology type

Using the F-test, the significance probability levels amongst all farmer types (in a row) for production, environmental and managerial technologies were 0.538, 0.528 and 0.613 respectively.