A stochastic spreadsheet model analysing investment options for the development of pasture on beef cattle farms.

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Abstract

The decision to proceed with farm development to increase animal production is complex. Standalone personal computer software to study either the financial or physical aspects of farm development is available, but models which integrate these components and account for the risks associated with the investment are not. A stochastic spreadsheet (Microsoft Excel®) model was therefore developed to predict the profitability, feasibility and risk of pasture development for two case farms: one in southern Brazil and the other near Wanganui in New Zealand. Pasture was developed at different rates for each farm and the model was used to predict the associated physical and financial changes over-time and a probability distribution of the net present values (NPV) of the net operating profit after tax and before interest (NOPAT) relative to the status quo situation. The extra pasture was used solely for increasing beef cattle production. On the Brazilian case farm the development of 2,263 ha at two rates was studied. The continuation of the status quo had first degree stochastic dominance in terms of the NPV over both development rates; it was superior by about NZ$ 46,000 for the 200 ha/y option and ca. NZ$ 110,000 for the 500 ha/y option at a 16% discount rate. However, at a 6% discount rate the 500 ha/y development rate had first degree stochastic dominance in terms of the NPV over both the continuation of the status quo (by about NZ$ 960,000) and the 200 ha/y option (ca. NZ$ 120,000). This indicates that pasture development could proceed profitability if interest rates continue to fall in Brazil as predicted. For the New Zealand case farm the development of 247 ha at 50 ha/y had first degree stochastic dominance over the 25 ha/y (ca. NZ$ 24,000) and continuation of the status quo (ca. NZ$ 208,000) at a 6% discount rate. Pasture development should therefore continue. Stochastic analysis of the pasture development investment options gave a better insight into the likely outcomes for a project, and provides the farmer with more information for making a decision on whether, and how, to proceed with farm development. The model could easily be adapted for studying farm development with respect to other types of livestock enterprises

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Chapter One: Introduction

Declining real returns for livestock products over the past decade and increased financial uncertainty have raised questions about the profitability of farm development for beef production in both New Zealand and southern Brazil. Few studies of farm development in the context of a less regulated and subsidised pastoral agriculture have been reported since the late 1970's, and those that have (e.g. Parker, 1978), generally have not formally accounted for production and price risk.

Computer models have become an important tool for predicting the likely results of on-farm investment. To date, most computer models have concentrated on a marginal analysis of the investment and not accounted for the whole farm system in terms of both physical and financial changes. Marginal analysis does not allow the 'big" picture to be shown of how the project is to be financed or of the farm's cash situation during the years of the development program. In addition, farming is a risky business and uncertainties about expected variation in production and product prices should be accounted for in the results of the investment analysis.

Thus, there is a need to revisit the question of whether farm development is profitable, and to utilise the increased power and flexibility of computers to analyse development options particularly with respect to risk. A computer model was therefore developed to consider the whole farm system. The model needed to reconcile the livestock numbers and production relative to pasture demand and supply, account for changes in costs and income forgone, estimate tax liability and reflect the farm's overall cash position. Risk was formally accounted only with respect to pasture production and the beef schedule price. These two parameters have a large influence on the outputs for a development program.

1.1. Scope and Purpose:

1.1.1. Objectives and hypothesis

The research reported in this thesis had four main objectives. The first was to select and assess the physical production and financial situation of two case farms. The second was to develop a computer model to describe the physical production and financial situation on the case farms. The third was to use the model to estimate the economic returns, financial feasibility, and risk of pasture development on the case farms. The fourth was to support the farmers' investment decision making by making the information on the probability of outcomes for alternative plans available to them.

The first two objectives were to evaluate the 'typical' production year and assess the impact of current beef cattle prices on the financial position of the farm. The third objective involved the selection of techniques to predict and evaluate the changes on the farm business through the introduction of improved pastures. The fourth was achieved by providing the farmer the information on the results for the development plan. The study hypothesis was that "Farm development for beef production in New Zealand and southern Brazil at 1996 costs and prices is profitable".

In summary, the model was built with the aim of answering the following questions:

- How does the actual farm system works? (status quo situation)
- Is the developed system financially better than the undeveloped one? (profitability)
- How does the farmer proceed form the "undeveloped" to the "developed" situation? (feasibility)
- What is the risk? (stochasticity of critical inputs)

Chapter Two: Literature Review

2.0. Introduction:

In this chapter the literature on-farm development and related topics is reviewed. The chapter is divided into three main sections namely: farm development, investment analysis and risk. In the first section, farm development and the problems of studying farm development in New Zealand and Brazil are presented. The role of personal computers in farm development planning is considered. The availability of computer software is discussed. The application of computer simulation models to assist decision-making in farm management is reviewed and the use of stochastic simulation as a means of accounting for risk is presented. Issues considered in model development like the whole farm approach, farm specificity and the discrete nature of farm development are introduced. In the second section, investment analysis criteria such as payback period (PP), net present value (NPV) and internal rate of return (IRR) are discussed. In the final section risk is presented and methodologies to account for risk in the process of decision-making are considered.

2.1. Farm Development:

The Oxford Dictionary (1989) defines the term development as 'The act or process of developing - to realise the potentialities of a farm by laying it out or building' (Hodgson, 1989; Simpson & Weiner, 1989). The term development plan, as used in this project, means the planning of the development of the farm business resources in the short- and long- term. It assumes that the potential for the farm to be developed and the goals of the farmer can be determined and incorporated in to the planning and decision-making processes.

2.2. Farm Development in New Zealand in the 60's and 70's:

New Zealand Governments have historically displayed a keen interest in the rapid and extensive development of rural land, because agricultural production was, and still is, the main source of overseas exchange (Maughan & Ward, 1978; Zwartz, 1996). Total loans by the government to the rural sector and the amount advanced specifically for land development purposes in the 1970's (Table 1), illustrate the involvement the government in the development of rural land (Terry, 1974; MAF, 1981).

Table 1: State loans to the New Zealand rural sector.

Year	Total Loans ($ millions)	Development Loans ($ millions)
1973-1974	59.40	12.29
1974-1975	103.17	25.26
1975-1976	139.26	31.18
1976-1977	154.34	38.11
1977-1978	227.90	62.47
1978-1979	292.89	109.97
1979-1980	306.93	121.00

Source: MAF (1981).

Irrigation loans, stock and plant loans, as well as the loans under the Livestock Incentive Scheme (MAF, 1979), are not included in the development loan data in the Table 1, but they may have further assisted the promotion and implementation of development projects. The Land Development Encouragement Loan (LDEL) was introduced in the 1978 Government budget with the objective of encouraging the development of unimproved or reverted land for pastoral grazing and other agricultural purposes. It was an attempt to maintain the rate of growth in exports from the agricultural sector through the development of marginal and reverted land. More than 953,000 hectares were developed under the scheme until its termination in March 1981 (O'Neil, 1980; Taylor, 1982). This program and others (MAF, 1976; Pryde & Martin, 1980) provided assistance to, and incentives for, New Zealand farmers to develop the productive potential of their properties.

Development of farms in the 1960's and 1970's appears to have been carried out with limited planning tools. Detailed studies on the potential for development were made (Cartwright, 1967; Parker, 1978) but, for most farmers experience, neighbours' information and professional advice, when available, where the main sources of information. Use of large amounts of fertiliser to increase soil fertility, installation of subdivision and a water supply, and oversowing to increase the presence of desired pasture species, were the main drivers of livestock farm development. Bank credit made initial development possible. After some years of development, when increased incomes became available, the rate of development usually increased because it could be funded out of reserves (Vallance, 1967; Riddles & White, 1974; Haines, 1987; Daniell, 1993).

2.3. Farm Development in southern Brazil:

A similar approach to land development assistance was adopted by governments in Brazil. During the 1960's and 1970's one of the major policy instruments to stimulate agricultural was the use of credit. From 1960 to the mid-1970's the real value of new agricultural loans increased more than six fold. Total agricultural credit as a proportion of agricultural GDP fluctuated between 65 and 94 percent in the 1970's. The overwhelming proportion of agricultural loans were made on a concessional basis, that is, the interest rate charged was usually substantially below the rate of inflation. For instance in the mid-1970's loans for agricultural inputs carried interest rates of 7 percent, whereas the rate of inflation exceeded 35 percent (Baer, 1995).

In the Brazilian case, however, the effectiveness of the subsidy programs as an instrument for improving farm productivity was limited to the modern segments of agriculture such as export crops (Table 2 and Table 3). Many factors contributed to the limited success of development loans in Brazil. Problems with unsupervised credit, as in the case of fertilisers, led to credit diversion to other uses. Lack of efficient rural extension services, education, and research are other important reasons for sub-optimal outcomes from development projects (Baer, 1995). Some beef cattle farmers in Southern Brazil used the government subsidised resources and achieved levels of productivity comparable with those of good farms in New Zealand. Most farmers, however, did not take up the opportunities effectively and continue to produce at the same levels as in the 1960's.

Some land development loans still exist for zones in northern Brazil but not for the southern states. Farms that were developed in the past are examples of what can be done when the resources are available and the objectives are consistent with the farmer goals.

Table 2: Average yearly growth rates of selected agricultural products in Brazil, according to principal market destination:

	1960 - 69	1967 - 76	1970 - 79	1978 - 89	1990 - 92
Internal					
Rice	3.2	-2.5	1.5	3.8	4.5
Beans	5.4	-1.9	-1.9	0.5	11.7
Manioc	6.1	-1.9	-2.1	-0.6	1.3
Corn	4.7	3.5	1.8	6.3	9.0
External					
Soybeans	16.3	35.0	22.5	8.8	-5.8
Oranges	6.1	12.7	12.6	7.9	
Sugar	3.6	5.1	6.3	6.6	1.8
Tobacco	5.3	-	6.2	-	
Cocoa	2.5	-	3.7	3.0	
Coffee	7.1	-6.3	-1.5	1.7	
Cotton	1.5	-2.0	-4.4	1.5	

Source: Baer (1995).

Table 3: Variation of area and production of the main 'modern' and 'traditional' crops in Brazil from 1970 to 1989.

Crop	Area (%)	Production (%)
Modern		
Cotton	-38.6	64.4
Rice	5.6	47.4
Sugar cane	143.4	228.8
Orange	335.3	482.7
Corn	24.7	77.0
Soybeans	767.8	1231.1
Wheat	69.6	175.5
Traditional		
Beans	41.6	3.7
Manioc	-8.7	-22.5
Bananas	76.0	10.5
Peanuts	-85.2	-82.7
Coffee	20.6	21.5

Source: Baer (1995).

2.4. Farm Development in the 90's:

If land development is to be carried out in southern Brazil or in New Zealand in the 1990's, it will only be with the resources available to the farmer and without government assistance. In both countries there remains scope to increase productivity and profitability on the farm (Edgecombe, 1988; Wright et al., 1989), and therefore potential to implement farm development programmes. Without government assistance development programs become riskier. The farmer and consultants will have to account for both price and weather variation when planning and implementing land development. Real agricultural product prices have dropped in the last 30 years indicating that increases in productivity, greater scale and/or lower unit costs of production are necessary to ensure profitability.

Land development opportunities may exist with respect to land use options such as dairying, deer, forestry or even housing, industrial development and recreational retreats (Pym, 1989; Harrison & Tranter, 1994). The methodology described in this thesis could be used to evaluate the profitability and risk of any land development option provided basic input data are available for the analysis.

2.5. Farm Development using Computer Models:

2.5.1. Personal computers

Personal computers (PC) at an affordable price to most farmers have only been available since the mid- 1980's. It is only some fourteen years ago that the first PC was marketed. Computers in the late 60's and early 70's required a large air-conditioned room for storage and capital and operating costs were high in relation to potential benefits (Ritchie, 1981; Nuthall & Bishop-Hurley, 1995).

More recently the Internet has become a source of information used by farmers and consultants. This speeds-up the flow of information and has the potential to develop into a widely used decision making tool. Weather forecasting and current information on commodity prices and the outlook for these are some example of the use of the Internet.

In New Zealand a postal survey in 1992/93 showed a rapid adoption rate of computers by farmers, with 24 percent owing computers and 19 percent of these using it for business purposes (Nuthall & Bishop-Hurley, 1995). The main business use of the computer on farms were financial recording, budgeting and word processing. The survey also stated that farmer demand for better software and training courses to improve farm computer use was increasing (Nuthall & Bishop-Hurley, 1995).

Parker et al. (1993) surveyed 250 seasonal supply dairy farmers and obtained similar results. Nineteen percent of farmers owned a computer and printer, and the computer was used mainly for financial recording, word processing, education and financial planning. A number of the respondents indicated that they planned to buy a computer when discretionary cash was available. The main reasons not to have a computer were lack of experience (60%), costs of computers (40%), and lack of time to learn how to use them (34%). Only 27% of the dairy farmers perceived that computers would not help their management.

2.5.2. Personal computer technology in developing countries

Ausher (1995) stated that microcomputer technologies in developing countries had the potential to support all the major functions of agricultural extension, namely technology generation, diffusion and adoption, and the efficient handling of descriptive, diagnostic, predictive and prescriptive types of information. This is because they provide the end-user with optimised options, data storage and retrieval, and superior accuracy and speed for manual calculations. They are a powerful educational and training tool, and can be used to prepare staff for more systematic fact-finding and for thinking in precise and quantifiable terms (Ausher, 1995).

In developing countries Williams (1993) and Ausher (1995) suggested that software development should concentrate in modest "down-to-earth" programs to answer specific technical questions not easily resolved without micro-computer support. Problems should be identified at a field level with focus on the farmer:extension interface rather than on more complex topics at the extension:research interface. Decision-making rather than mere data-processing should be the focus of software development (Williams, 1993; Ausher, 1995).

2.5.3. Farm computer software in New Zealand and Brazil

Some examples of agricultural software commercially available in New Zealand are: Concept Cash Manager - a financial recording software with limited forecasting power (Clark, 1995); DairyMan - recording/retrieving system for dairy farms and dairy consultants (Hayes, 1994); Stockpol - a simulation model for physical and financial changes in stock policy (Marshall, 1991); Outlook - a simulation model to predict production and economic responses for sheep, beef, and dairy farms under different fertiliser regimes (Baars, 1995); Farm Tracker - a recording/retrieving system with feed budgeting and pasture growth simulation (Butler, 1994); Udder - a simulation model to predict outcomes of changes in management and pasture growth for dairy farms (Larcombe, 1989).

Most of the software are databases for financial and physical recording. They are of limited use for long-term farm planning and control, because few provide simulation for forecasting and none of them take account of price and production risk. Effort is being made by universities and research institutions to improve farm computer software. Lack of experimental data in a format that can be readily incorporated in computer models, and farm specificity are some of the problems in developing computer software. The small market for farming software and the time and expertise necessary to build them may, in many cases, not be sufficient to compensate for the development and marketing costs. In Brazil, fewer farm-related software are available than in New Zealand and those that have been released are, generally, databases for financial and animal data recording systems with no simulation capability.

2.5.4. Simulation models

Simulation is a relatively recent addition to the strategic and operational planner's tool box. It can provide cost-savings when different strategies can be proven under 'real-life' conditions at the planning stage. The technique provides quantitative information for return-on-investment analysis for alternative strategies in many business sectors (Carlile, 1987; Jepsen, 1991).

For farming however, simulation alone may lead to an incorrect judgment being made of alternative plans (Murhy, 1969; Monke et al., 1992). Farming is risky and the use of one set of average or 'best guess' values ignores risk (Murhy, 1969; Anderson & Dillon, 1992). Techniques to incorporate risk in computer models are discussed in Section 2.18.

2.5.5. Computer models in farm management decision-making

Computer models, for the purpose of this study, are defined as a mathematical representation, in a simplified form, of the aspects of a real system relevant to the purpose of which the model was built (Dent & Blackie, 1979; Wallis, 1992; Baars, 1995). In this case the system being represented is the farm business. The farm business comprises both the financial and physical (biological) components of the farm.

The use of computer models as a planning tool for on-farm decision-making has being discussed by numerous authors (Pearson, 1991; Monke et al., 1992; Leeg, 1994; Baars, 1995). Farm management can be assisted in four ways: long-term decisions, strategic planning (for next year or the next few years), tactical (day-to-day) decisions and on-line (operational) decisions (Leeg, 1994).

Computers are increasingly being used for long-term decisions like investment appraisal. In such cases, computers are able to support the farmer by handling a large amount of data very rapidly, and by taking many factors into account simultaneously. Right decisions cannot be made without a careful assessment of the total farm system in which the new technology, equipment, or building will operate (Leeg, 1994).

It should be stressed that the results produced by the model are mainly the product of two things; the assumptions made by the modeller and the biological theory that shaped the way the model was built (Wallis, 1992; Baars, 1995; Sandrey, 1994). Models should therefore be subjected to peer review and validation to ensure that the functions simulating biological processes are consistent with current knowledge of the natural systems that they mimic (Dent & Blackie, 1979; Baars, 1995).

The use of computers to account for the whole farm system is not a recent idea (Robinson, 1983) and the importance of the whole farm simulation model approach has been addressed by several authors (Lodge & Frecker, 1990; Udo & Brower, 1993; Leeg, 1994; Nyangito et al., 1995). For a model to give useful answers for investment analysis it needs to account for the changes to the whole farm system that could be caused by implementing the alternative plan and the assumptions in the model have to be valid for the specific farm (Leeg, 1994).

Development of computer software for use in farm-specific decision making is a difficult task. The amount of data required for the model to give a customised result is often large. The results of the model reflect the quality of the data provided and the assumptions made by the modeller. The user, whether it is a farmer or advisor, needs to be aware of the assumptions and recognise the limitations of the model (Carlile, 1987).

2.5.6. The discrete nature of farm investment

Computer models for planning farm development need to consider the discrete nature of some investments. To mimic the real situation, the model needs to account for land being developed sequentially over time and the consequent effects on animal production, income, and expenditure (C.A.B.Trust, 1992). It has to describe the initial state of the farm and predict the income and expenditure for the years to come.

Development is often made in discrete amounts because a learning process occurs through time as the farmer gains new knowledge year by year about the processes that takes place. This can increase the efficiency of development by decreasing costs and improving results (Glen, 1996).

Glen (1996) designed a model for developing deer farms. This model simulates the cash flow for the whole business for a pre-established planning horizon. The model takes into account the discrete nature of the investments required to establish a new livestock enterprise or to expand a policy for an existing farm. A steady state linear programming approach is used to identify the best combination of live stock ages for the enterprise (Glen, 1996).

2.6. Investment Analysis:

Methodologies used to analyse alternative investment decisions are design to provide specific information about the characteristics of the investment. These techniques by no means provide a complete answer to a particular investment problem, but they do provide a systematic framework within which extra inputs and expenditure to a farming system can be considered. Better informed and documented decisions can be made by understanding the principles, advantages and limitations of investment methods (Speedy, 1968). The aim is to provide high quality up-to-date information to the decision-maker at the time the decision is made (Makeham & Malcolm, 1993). This provision of information does not free the individual farmer concerned from having to make the decision and living with its consequences, but it does attempt to confine the extent of the unknown (Whipple, 1988). Payback Period (PP), Net Present Value (NPV) and Internal Rate of Return (IRR) are the most widely used indicators of the suitability of an investment appraisal.

2.7. Time Value of Money:

From an investment point-of-view, one dollar today is worth more than one dollar in the future, unless interest received on that dollar exceeds the rate of inflation. Interest is paid in relation to the lender's opportunity cost of the money and the perceived soundness of the borrower's venture. Other reasons for the time value of the money are consumer preference and risk. From the consumer's point-of-view, it is better to spend money today to buy products, than to wait until some future point in time to buy the same (similar) product. Finally, from a risk point-of-view, one dollar today is worth more than one dollar in the future because of the risk of some unforseen circumstance preventing the dollar being recovered (Kay & Edwards, 1994).

In investment analysis the way time value of the money is considered is important because if money is to be borrowed, interest usually must be paid. Similarly if the farmer's own equity is used there is an opportunity cost of earnings which must be considered. For example, a farmer could receive interest on his/her money or the equity could be used for consumption (Boehlje & Eidman, 1984).

2.8. Discount Rate or Interest Rate:

Discount rate and interest rate express the change in money value over time, in percentage terms. Interest usually refers to the rate charged on debt capital. The discount rate refers to the value used to express future monetary values to present day terms. Money received in the future, for example through farm development, is discounted by the discount rate to its present value in order to compare investment options. For project appraisal purposes the discount rate is used to calculate the Net Present Value (see Section 2.10 for definition of this term) and determine the profitability of the project. The discount rate may be calculated in several ways depending on the source(s) of project capital and the procedure used to account for risk and inflation.

Nominal discount rates are used when all values in the project are accounted for in nominal values, or values which include inflation in the cost and revenue streams. A real discount rate is used when all costs and revenues for the project are accounted for in real values. Real values exclude the effects of inflation on costs and revenues and the discount rate. In other words the use of real values assumes that future costs and revenues increase at the same rate i.e. they are synchronised (Whipple, 1988; Levy & Sarnat, 1990).

An allowance for risk can be included in the real discount rate (McCarthy, 1994), by adding a risk premium. The risk premium, a percentage value, accounts for the perceived risk of the project. Alternatively, the real discount rate can be determined by the return offered by an investment perceived to have similar risk (Jefferies, 1996). Using this methodology, money received in the long-term is less valuable, and the comparison between investments perceived to have similar risk will favour investments that have a shorter-term. Another option to account for risk is to estimate the variability of the expected outcomes from the project rather than account for risk in the discount rate. The latter option is used in this project.

The value of the real discount rate can be chosen in relation to the source of capital used in the project. If money is borrowed, the interest rate paid would be used as the discount rate. It should be noted whether the interest paid is tax deductible, since where this applies, the real cost of debt capital to the farm is the interest rate on debt funds minus the tax savings (Boehlje & Eidman, 1984). Alternatively, an after-tax real discount rate can be used to evaluate the whole project on an after-tax basis (Blaney & Bright, 1995).

If the farmer's own equity is used to finance the project, the discount rate may be determined as the farmer's own perception of the opportunity cost of equity capital. The farmer may use a cut-off discount rate based on the perceived risk of the project. Thus the cut-off value is considered to be the minimum return the farmer is willing to accept on equity invested in the project. One approach for estimating the discount rate is to use the after-tax rate of return on equity capital used in the firm (Boehlje & Eidman, 1984).

A combination of equity capital and debt is often used to finance farm projects (Kincheloe, 1990; McDermott, 1995). In these cases the discount rate should be equivalent to the weighted cost of the two sources of capital, i.e. the Weighted Average Cost of Capital (WACC) (Kincheloe, 1990). The expected long-term combination of debt:equity for the farm could be used to derive the WACC. Alternatively, the actual debt:equity ratio of the business can be used. However, the discount rate cannot be changed year by year to reflect the expected change in the debt:equity ratio of the business during the project (Kincheloe, 1990), unless the change in each discount rate is proportional and as a consequence the overall discount rate does not change (Ling, 1992). By using this approach a positive NPV will only be achieved when the farmer and the creditors receive their expected rates of return (Kincheloe, 1990).

2.9. Payback Period:

Payback period (PP) is the time the project takes to earn the amount of money invested plus the interest paid on this investment. It is the time needed for the project to pay its costs through the net cash revenues that it generates (Kay & Edwards, 1994). For farm investments the PP is usually expressed in terms of years.

The PP is a measure of how fast the investment will contribute to the overall liquidity of the business. However payback period does not measure the profitability of the investment, because it does not take into account the revenues after the investment is paid back. It may be used to find out which investment gives the most immediate net cash returns (Kay & Edwards, 1994).

If borrowed money has to be repaid to the bank, the PP can indicate how soon the mortgage can be terminated with money generated from the investment (Blaney & Bright, 1995). The use of PP as the single criteria for investment analysis can easily lead to poor investment decisions because more profitable investments with longer-term PP's will not be selected.

2.10. Net Present Value:

Net Present Value (NPV) is the monetary value of future income streams presented in today's values. It is calculated by discounting future monetary values through the discount rate to today's values hence the term Discounted Cash Flow (DCF) method, which has been widely discussed in the literature for investment appraisal expresses the stream of cash flows (NPV) over the entire life of the project as a single value (Whipple, 1988; Robinson, 1989; Williams, 1993; Kay & Edwards, 1994; Blaney & Bright, 1995; Jefferies, 1995; Jefferies, 1996).

The proper construction of the DCF model for the firm forces the analyst to identify the assumptions made concerning costs and returns including how they are defined, their magnitude and their timing (Whipple, 1988). The DCF method is superior to the capitalisation method (discussed in Section 2.14) when the value of the project is dependent on future irregular cash flows such as for the development of horticultural and forestry blocks (North, 1985; Jefferies, 1995).

The NPV measures the profitability of the investment option. In terms of a decision rule, all projects with positive NPV should be implemented and, if mutually exclusive, the project with the greater NPV value should be selected. The NPV can be understood as the value an investor could pay for the project to achieve the return of the discount rate chosen (Kay & Edwards, 1994). The estimate of the NPV will be as accurate as the predictions on the amount and timing of expenditures and revenues (Jefferies, 1996).

Costs and revenues for the same kind of project vary between farms, thus farm-specific studies are necessary to give the best NPV appraisal for a particular farm (Whipple, 1988; McCarthy, 1994).The analysis should incorporate the best information available at the time of decision-making. In order to test how sensitive the NPV is to the assumptions made the analyst can generate sensitivity analysis tables (McCarthy, 1994); use weighted best, worst, and most likely scenarios (Whipple, 1988); or adopt results from stochastic programming (Murphy, 1969). It is inevitable that forecasts for farm investments will not match reality. Rather DCF forecasts, by allowing management to identify those components of cash flow that contribute most to deviations from expected outcomes, should lead to improved decision-making by management (Jefferies, 1996).

The choice of discount rate is a crucial part of the investment analysis (Boehlje & Eidman, 1984; Whipple, 1988; Locke, 1990; Jefferies, 1995), since it will determine the NPV of the revenues to be received in the future. A project with a positive NPV at a given discount rate will ultimately have a zero NPV if the discount rate is increased and this will become negative at an even higher discount rate. Thus, the same project could be selected or rejected depending on the discount rate chosen.

When comparing projects with different expected lives, the choice of the discount rate may benefit one project over the other. If a low discount rate is chosen, long-term projects will benefit because revenues obtained in latter years will have larger present values. On the other hand, if high discount rates are chosen short-term investments will be comparatively better off.

When comparing projects where different amounts of money are invested, the NPV may be greater for the most expensive project but the cheaper project may offer a better return on the actual capital invested. It may be a case of looking at the possibility of undertaking more than one of the cheaper projects in order to earn an even better NPV. Obviously, farming is not that simple and other constraints such as land and labour may prevent this multiple-project approach.

An implicit assumption of the NPV method is that values earned through the life of the project can be invested and earn interest at the same value as the discount rate (Selvavinayagam, 1991). This assumption is likely to be true if the chosen discount rate reflects the real interest rate paid in the market. Again, the choice of the discount rate is very important.

2.11. Net Future Value:

Net Future Value (NFV) is the future value of a given amount of money today. It has the same advantages and limitations of the NPV method because it is, in fact, simply another way of looking at the same values. Instead of looking at the projects in today's values the investor (farmer or consultant) will be looking at the values at some point in the future. For project appraisal purposes, NPV is generally preferred because it is easier for decision-makers to relate to the buying power of money today than at some time in the future.

2.12. Internal Rate of Return:

The Internal Rate of Return (IRR) is defined as the discount rate at which the NPV, for an investment project is equal to zero. It is a measure of the profitability of the investment. It is also called marginal efficiency of capital or yield on the investment. The decision rule is to invest in any project for which the IRR is greater than the discount rate or the cut-off value determined by the investor. The implicit assumption of the IRR method is that all revenues earned in the life of the project can be invested at a rate equal to the IRR until the end of the project (Selvavinayagam, 1991). This assumption is generally not true for farming investments and may favour investments where higher returns are gained in the first years of a project or investments that have a lower cost, as stated before in relation to the NPV criteria.

Where IRR analysis is used and an initial investment value is assumed, care should be taken to ensure that the result is valid because mixed cash inflows and outflows during different time periods can result in multiple IRR solutions (Jefferies, 1995).

2.13. Economic Life:

The economic life of the project will influence its NPV and IRR. The assessment of the life of the project and the cash revenues throughout its life are the basis of the calculations of NPV and IRR. Care should be taken when comparing projects with different 'lives' using the IRR and NPV methods for reasons stated earlier. The ranking of two projects with different lives may vary when using the NPV and IRR methods. A project with a short life and lower cost may be ranked first by the IRR method but last by the NPV method (Kay & Edwards, 1994). Again the assumptions used in relation to the methods need to be accounted for when making the decision on whether to proceed with a project.

A project can have an unlimited life. For example, the development project for a farm will continue to earn profit for as long as the land is farmed. In this case a salvage value, as explained in the next section, has to be derived to account for profits earned after the project has concluded (Boehlje & Eidman, 1984).

2.14. Original and Terminal Value:

At the end of the project a salvage value for improvements may be realised. The salvage value can be understood as the value of an asset at the end of its life, and may be calculated as the original value of the asset less the depreciation. The discount rate chosen for the NPV calculation will influence the present value of the salvage value. The salvage value has little influence on the NPV when the appraisal applies to a long-term project using a high discount rate.

In the case of development projects the salvage value may be the perpetuity value of the project, if it is assumed that at the end of the project it will produce the same on-going stable profit (Boehlje & Eidman, 1984; Locke, 1990; Jefferies, 1995). This approach, called the capitalisation method (Equation 1) (Bradley, 1989; Martin, 1993; Gray, 1995), can be calculated by dividing the present value of the profit of the last year of the project by the capitalisation rate. The capitalisation rate is the discount rate from where the expected growth rate is deducted (Bradley, 1989). If the discount rate is used instead of the capitalisation rate, the project is assumed not to influence further growth in the business returns (Boehlje & Eidman, 1984). Again the discount rate is critical in determining the capitalised value.

$$SV = \frac{I}{d - g}$$ **Equation 1**

Where:

SV = salvage value;
I = income after tax;
d = discount rate;
g = growth rate.

The salvage value in a farm development project can be considered as the added value of the business for increased capacity to generate income (Gray, 1995). The calculated value may not mean extra income if the farm is sold because other factors may have a greater influence in the sale price (Hodgson, 1989). This approach is valid when the farmer is developing the land with the objective of increasing the profitability of the business, and not planning to sell the farm at the end of the project.

2.15. Inflation:

Inflation is the reduction in buying power of money over time. The buying power of a farm's net revenue is maintained if items of expenditure and income change in value at the same rate and there is no delay in the adjustment. In these circumstances, which are extremely rare, inflation would not affect the results for the business. In nearly all cases, inflation affects farm income and expenses differently and the buying power of the net farm revenue may increase or decrease as a consequence of this (Freebairn, 1981; Whipple, 1988).

Inflation is accounted for in the nominal interest rate of debt capital as an adjustment to the expected rate of inflation over the period of the project (Bierman & Smidt, 1986). If a mortgage interest rate is fixed, and inflation is greater than expected, the borrower achieves real gains from the increase in the sale price of products in relation to the interest rate charged. Banks seek to have good information when choosing the interest rates to charge in order to minimise such losses.

In the case of Brazil very high real interest rates have been common since 1986. These interest rates are consequence of 'economic plans' implemented in order to make the transition between a very high inflation period to a more stable economy. Investments have to earn high returns in order to be profitable in this economic environment (Baer, 1995).

The inclusion of taxation and debt under inflationary conditions leads to problems in the appraisal of projects. Inflation means any tax relief received on capital investments will have a lower present value. Tax reliefs are often related to a depreciation schedule and inflation erodes their value in present terms (Williams, 1986; McCrea et al., 1990; Levi & Sarnat, 1990). When inflation is incorporated in the interest rate of debt capital it is termed the nominal rate. This nominal interest rate is tax deductible and the deductions from the nominal interest rate may exceed the real interest rate. Thus, in some circumstances the real interest paid may be negative (Williams, 1986; McCrea et al., 1990) and because of this, in countries with chronic problems of inflation, such as Brazil, 'inflation proof' indices are used instead of nominal values to calculate the tax implications of investments based on debt capital (S.R.F., 1995).

2.16. Financial Feasibility:

Financial feasibility is concerned with whether the money required to finance the project will be available in sufficient amounts and at the appropriate times (Blaney & Bright, 1995). For any investment decision the analysis must consider both economic profitability (i.e. the NPV and IRR values) and financial feasibility (Boehlje & Eidman, 1984).

A project's financial feasibility is influenced by the assumptions made in relation to cost and revenue streams. Sometimes projects with long payback periods can be regarded as infeasible because of difficulties in obtaining funding for such long periods (Blaney & Bright, 1995). Another problem may be that the debt to equity ratio may reach a level where banks may either be unwilling to lend money to the business (Whipple, 1988) or increase the interest rate because of their perception of increased risk. A debt profile, constructed alongside the DCF values, shows the amount of capital outstanding on an annual basis and the payback period can be used to estimate feasibility (Blaney & Bright, 1995).

2.17. Risk:

Risk is an integral part of daily decision-making in the management of agricultural systems (Parker et al., 1994). For the purpose of this project, risk is defined as the probability of reaching or not reaching a certain result due to uncertainties associated with forecasting data about the results (Held, 1990; Johnson, 1993; White, 1994). Risk and uncertainty are used with the same meaning, although Knight (1921) distinguished the terms on the basis of the type of data available. Uncertainty applies in situations where only a subjective assessment of the likely outcomes associated with a particular event can be made, whereas risk applies where objective data is available to test the prediction upon.

The types of risk considered in this project are 'business' risk and 'financial' risk. Methods of accounting for these types of risk in investment decision are presented in this section. The aim of risk management is to provide the decision maker with the best possible information in an organised form from which s/he can derive a decision (McFarquhar, 1960).

Agricultural producers usually must select a course of action before they know its consequences. The consequences depend both on the actions they choose and on future events that are beyond their control (Fleisher, 1990).

Given the predominance of risk in agriculture and recognising that uncertainty about costs and returns are important determinants of investment behaviour (Purvis et al., 1995), agricultural economists have attempted to provide information in a way that make elements of risk clear to the decision-maker. Recommendations based on point estimates of expected profitability of different alternatives are inadequate for this purpose (Officer et al., 1967; Upton & Casey, 1974; Hardaker et al., 1991), but are widely used in practice.

Although it may be argued that risk information may result in no action being taken, farmers would appreciate more rather than minimal information for decision making (Officer et al., 1967; Hardaker et al., 1991). Information about risk provides decision-makers with a more rational basis for choosing between alternatives (Halter & Dean, 1971; Upton & Casey, 1974). It is worth noting however, that a 'good decision' does not guarantee good outcome. Decisions derived from careful and reasoned analysis might still have "bad" outcomes in any particular instance. Nevertheless, when risk considerations are accounted for at the planning stage, deviations from the plan can be anticipated and actions to minimise adverse effects can be implemented.

2.17.1. Business risk

Business risk is the risk of the farm independent of the way it is financed (Boehlje & Eidman, 1984). There are two major external sources of business risk in agricultural systems. One is the market, where the uncertainty of prices for inputs and outputs, results in price risk. The other is the biophysical environment, where production is influenced by variable states of nature, and this results in production risk (Gabriel & Baker, 1980; Eidman, 1983; Martin, 1994). Business risk can be evaluated at a point in time through the probability distribution of net cash flows associated with a particular decision (Gabriel & Baker, 1980).

2.17.2. Production risk

Production risk is represented by the probability distribution of the physical outputs of the farm. For grazing systems it is the probability distribution of animal production from year to year. Variable outcomes results from factors (states of nature) beyond the farmer's control such as rainfall, soil temperature, frosts, and snow, and the management strategies put in place by the farmer minimise their negative impact on animal production. Thus, two neighbouring farms with very similar systems of production, may have different production risk given the same climatic events because of differences in management between the farms.

Production risk is characterised by the probability distribution of output measures such as yields per hectare, weaning weights, rates of liveweight gain, and animal losses (Boehlje & Eidman, 1984; Rosegrant & Roumasset, 1985). Orskov & Viglizzo (1994) suggest that the consequences of climatic variation in animal production are less pronounced than in a crop production system because animals buffer climatic variability.

The provision of historical and forecast data, especially variance and covariance information, by research and extension personnel to the producer can play a critical role in the process of accounting for production risk. Providing a more complete and useable set of information to producers is one way to help them evaluate the possible outcomes of their decisions (Patrick & DeVuyst, 1995).

2.17.3. Price risk

Price risk can be represented by the probability distribution of the prices of inputs and outputs for the production system. Input prices are often less variable and have less impact on the final result of the business than the price of outputs. Seasonal and cyclical trends in prices are predictable to some extent, but the inability of the farmer/consultant/economist to predict these prices with certainty exposes the farmer to price risk (Fleisher, 1990). If past prices have closely followed a trend, such as a climatic season, and nothing foretells a change in the trend, forecasts of future prices can be made with reasonable accuracy (Fleisher, 1990) and used in risk models (Walker & Helmers, 1984). However, in many cases in agriculture, especially for commodities, a large number of factors generate the price which the farmer finally receives, and variation in any of these factors (e.g. exchange rate, interest rates, seasonal supply and demand) may cause final prices to vary substantially both within and between years.

2.17.4. Financial risk

Financial risk is essentially the risk of being unable to meet prior claims on the farm with the cash that it generates (Gabriel & Baker, 1980; McCrea et al., 1990; Martin, 1994). It may be added to (Eidman, 1983), or multiplied by (Boejlhe, 1993), business risk to represent the overall risk of the farm.

Two factors may be critical in determining financial risk. First, the initial debt situation of the farmer influences how much of profit is used to service debt and how much is available for investment. Second, the amount and timing of expenses and returns on the investment will influence cash flow and liquidity. If the investment has a high initial cost and returns are delayed, it may be difficult to get a mortgage for such a long period of deficit (e.g. plantation of trees for timber production) or, alternatively, bankruptcy may occur due to the cost of capital relative to the farm's cash flow.

2.18. Accounting for Risk in Investment Decision Making:

The recognition of the importance of risk in planning and decision-making is not new (McFarquhar, 1960; Halter & Dean, 1971; Trebeck & Hardaker, 1972; Bell, 1977; Hodgson, 1989). In fact, the search for methods to introduce risk in to planning and decision-making methods has generated many techniques. A common aspect of these techniques is that they attempt to provide a systematic approach to decision-making under conditions of incomplete knowledge.

2.18.1. 'Thin' or 'Fat' coefficients

The introduction of 'thin' or 'fat' coefficients during the planning stage to provide a security margin is widely used by farmers and their consultants. The use of a 'fat' coefficient in the discount rate when evaluating a project under the NPV technique is a common practice (Johnson, 1992; Painter & Schoney, 1994). Hardaker (1979) also suggested 'thin' or 'fat' coefficients as a way of introducing risk into linear programming. This method would ensure that the solution remained feasible if the uncertain inputs were smaller or bigger than expected.

The use of 'thin' or 'fat' coefficients for production inputs, price inputs, and the discount rate would have an accumulative effect on the project's 'expected' NPV. As a consequence, when this approach is used to compare two different projects, the amount of security margin needed for elements in each project would be a potential problem (i.e. the coefficients could be very different for each project).

2.18.2. Sensitivity analysis

Sensitivity analysis is a technique to determine how sensitive output is to variation in the inputs used to generate the output. Sensitivity analysis has been proposed as a means of getting more information about the possible outcomes from a proposed plan. For example, software developed to assist decision making, could be run for many times using different assumptions to come up with many possible scenarios (Hardaker, 1979). With increased computer power it is possible to run a wide range of scenarios quickly in order to estimate response 'surfaces' for a particular decision (Hinman et al., 1984).

One problem with the sensitivity analysis is that the likelihood of the outcome is not considered (Bell, 1977; Johnson, 1993). The decision maker has to introduce his/her own beliefs on the likelihood of the variation in inputs to derive their decision. A further problem arrives when more than one or two variables are to be tested, because the number of possible outputs would almost certainly defy assessment and interpretation of the overall uncertainty of the system (Bell, 1977).

2.18.3. Bayes' theorem

Bayes' theorem, an elementary theorem of probability, was originally derived in the eighteenth-century by Thomas Bayes. It provides a logical mechanism for the consistent processing of additional information about probabilities of uncertain factors (e.g. prices). The theorem states that the posterior probability of an event is proportional to the prior probability times the likelihood (Anderson et al., 1977). Thus, different plans can be evaluated in terms of the available information about the risky variables and the likely outputs. Discrete probabilities for the possible outcomes for the plans being compared, are defined in terms of the chance of achieving a good, bad, and average output. The expected value(s) for the different plans are the weighted average of the possible outcomes and the plan with the highest expected value is then selected (Nuthall, 1974). Bayes' theorem is a helpful tool when sequential decisions have to be made and information becomes available during the process. However, the approach is limited due to the use of a single value to rank the alternative plans. Also the information about the variance associated with the possible outputs for a plan are not stated clearly for the decision-maker. It is possibly for these reasons, and initially because of a lack of access to computing power, that Bayes' theorem has not been adopted at the farm level for decision making.

2.18.4. Quadratic programming

Quadratic programming was the first attempt to explicitly account for risk in mathematic programming formulations of whole farm plans (Anderson et al., 1977). The work of Markowitz (1952), cited by Johnson (1992), was the basis for this approach and lead to the development of the mean-absolute deviation efficiency (MOTAD) and Target-MOTAD techniques, which have lower computing requirements (Rawlins & Bernardo, 1991; Jha, 1995). The latter techniques are used to optimise the mean-variance (E-V) for a set of projects. The most efficient set of projects are those closest to the E-V efficient frontier. Risky choices can partially be ordered for decision-makers using this approach (Barry, 1984), but the utility function of the decision-maker is needed to select the optimal plan for his/her situation (Officer et al., 1967; Nau, 1995; Pannell, 1995). While risk is accounted for in the net revenue values, other inputs are entered as constraints and are still deterministic. The net revenue is generally represented by mean, variance and covariance between activities, assuming a normal distribution (McFarquhar, 1960; Anderson, 1975). Farmers who choose plans closer to the E-V efficient frontier are said to be more 'efficient' in the process of decision-making;

nevertheless, in many cases, sub-optimal plans may be preferred due to the effect of factors not accounted for in the E-V calculations.

2.18.5. Stochastic simulation

The use of stochastic simulation to account for risk has been proposed by several authors (Rosegrant & Roumasset, 1985; Hardaker et al., 1991; Selvavinayagam, 1991; Anderson & Dillon; 1992; Weersink et al., 1992). The advantage is that it gives much greater insight into the nature of an investment project and how future performance is likely to be affected by stochastic influences (Murphy, 1969). The process ensures a more realistic result and a better documented decision (Monke et al., 1992).

The term stochastic can be used to explain both unexplained events and the events that are truly random (Dent & Blackie, 1979). In stochastic models uncertainty is explicitly included, so that the model, in its totality, reflects the degree of understanding that the modeller has of the real system. This is very important for decision support models because decision-makers should be aware of the assumptions made by the modeller (Dent & Blackie, 1979).

Stochastic inputs are entered as probability distributions rather than a single value. The probability distributions can be non-normally distributed and correlated (Weersink et al., 1992). The probability distributions are then simulated in a model that describes the system. The Monte Carlo technique (Hammersley & Handscomb, 1964), or a similar sampling technique, is used in the simulation to generate the probability distributions for outcomes.

Similar methodology is recommended by FAO to be used in investment appraisal in dryland farming systems (Anderson & Dillon, 1992). Production risk, due to climate variability, is critical for decision-making in these conditions. Stochastic computer models with the same approach were developed and used to evaluate alternative East Coast Fever control strategies in Eastern, Central and Southern Africa. Price and production risk were evaluated to decide between alternatives. In this simulation, two case farms where chosen and the results were farm-specific (Nyangito et al., 1995).

The 'best' source of data to build the probability distributions required depends on the objective of the research. If the objective is to forecast the outcomes of different plans, based on variables best described by historical data, a statistical procedure utilising historical yields would be preferable (Pease, 1992). One example is the use of rainfall data in stochastic models (Angus, 1991). Each month can be described by a probability distribution of rainfall. Random samples are then taken from each distribution by simulation, to create a probability distribution of outcomes for the action being tested (Dent & Blackie, 1979; Angus, 1991). On the other hand, if the objective is to reflect individual farmer uncertainty, representation of the farmer's subjective uncertainty to define the probability distribution is preferable (Pease, 1992).

Alternatively both farmer's subjective judgments about the stochastic input distributions and historical data can be used to build the probability distributions (Purvis et al., 1995; Torkamani & Hardaker, 1996). Research data shows à close correspondence between historical records and a farmer's forecast can be expected (Pease, 1992). This consideration is important for development plans where local data is scarce (Orskov & Viglizzo, 1994).

More complex simulation models may give better results but difficulties in interpreting, explaining and justifying the results of the simulation may lead to limited acceptance by potential users (Greer et al., 1994). Better presentation of the data and courses for farmers and advisors may be needed to increase the acceptance of such models.

2.18.6. Stochastic efficiency

Stochastic simulation may lead to the production of many probability distributions which have to be examined by the decision-maker in order to select the best course of action. The pre-selection of stochastic efficient plans can decrease to some extent, the number of plans which need to be considered in order to reach a decision (Anderson & Dillon, 1992). The efficiency criteria to achieve pre-selection are progressively selective but a disadvantage is that restrictive assumptions have to be made about the utility function of the decision maker. For the purpose of this project first and second degree stochastic efficiency are presented with the aim of decreasing the number of possible alternatives without making assumptions about the decision-maker's utility function.

2.18.7. First degree stochastic dominance

Under the first degree stochastic dominance (FSD) criteria an alternative with an outcome distribution (e.g. net revenue) defined by the cumulative distribution function F(y) is preferred to a second alternative with a cumulative distribution G(y) if $F(y) \geq G(y)$ for all possible values of y from 0 to 1, and if there is inequality for the distributions for some value of y (King & Robison, 1984). This method assumes that the decision-maker prefers more than less in terms of profit. While this would seem to be a very reasonable assumption, in some cases this decision rule may not eliminate many alternative plans (Smidts, 1990).

2.18.8. Second degree stochastic dominance

The second degree stochastic dominance (SSD) rule assumes that the decision maker is risk averse. In other words the decision maker has a strictly concave utility function. Under this circumstance for all risk averse decision makers, alternative F(y) dominates alternative G(y) if:

$$\int_0^x [F(y) - G(y)]dx \geq 0$$

for all levels of x in [0,1] and if there is inequality for some value of y (Smidts, 1990).

2.19. Summary/conclusion:

Farm development in the 1990's, without government assistance, requires careful planning. Computer stochastic simulation models are a useful tool for planning because they allow a greater amount of data to be processed simultaneously, and this can provide the farmer with more information about the likely results and risk. This information, in an organised form, can help the farmer to derive decisions. In the next chapter the two case farms used in this project to evaluate a pasture development programme are presented.

Chapter Three: Farm Description

3.1. Brazilian case farm description:

3.1.1. Location

The Brazilian case farm is located near the city of Bage in Rio Grande do Sul State (Figure 1). Rio Grande do Sul is the southern state of Brazil. The city of Bage is located in the south-east region of Rio Grande do Sul between 30° 31' and 31° 56' South of the Equator and between 55° 30' and 54o 30' West of Greenwich. The southern boundary of the city is the north of Uruguay.

Figure 1: Location of Brazilian case farm.

3.1.2. Climate

The climate is listed as sub-tropical mesotermic cfa in the Köpen classification (Goncalves et al., 1988). The average rainfall is 1300 mm per year with a tendency for more rainfall to occur during the winter. The average annual temperature is 16.6°C and monthly averages vary from 24°C in January to 12.5°C in July. The temperature extremes are -4°C and 41°C. The relative air humidity varies between 75 to 85% and frosts occur between April and November with the greatest incidence of these occurring during July and August.

3.1.3. Soil types and natural chemical fertility

The two predominant soil types on the case farm are locally called "Bage" and "Acegua". The Bage soil, which originated from silt rock is a vertic planosol with clay texture set on easy rolling topography. The Acegua soil type, a vertisol, occurs on rolling topography and originated from clay-silt rock. Both are classed as "heavy" soils due to their high clay content.

The pH of the soils varies between 5 and 5.5 and there is no toxic aluminium present. Lime is therefore not recommended. The phosphorus (P) levels, measured by the Melich test on soil sampled to a depth of 20 cm, varies from 1 to 5 ppm[1]. Potassium (K) levels are high. The primary limiting chemical fertility problem of those soils is P. The most widely used forms of P fertiliser to correct this deficiency are single superphosphate or triple superphosphate.

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[1] The depth of the sample will influence the result of the test due to most of the P being present in the first 5 cm. In New Zealand the soil is sampled to 7.5 cm

3.1.4. Area and pastures

The case farm is a 5058 ha beef-cattle/irrigated rice crop property, with an additional 1002 ha of neighbouring leased land. Land use is shown in Table 4.

Table 4: Total area divided by land use for the Brazilian case farm.

Soil utilisation	Owed	Leased
Native pastures	2086	178
Fertilised pastures	345	-
Improved pastures	787	185
Pastures (last year's rice area)	556	204
Irrigated rice	595	191
Sorghum	110	-
Forestry	48	8
Native forest	15	10
Dam and houses	476	142
Swamp	40	-
Not used	-	84
Total	**5058**	**1002**

Source: Martins, 1996 (pers. comm.)

The native pastures on the predominant soil types of the case farm comprise up to 62 grass species and 13 legume species. Some of the most common better quality grasses and legumes are presented in Table 5 and Table 6 in relation to the soil type they are established on and their rate of occurrence.

In this thesis fertilised pastures refers to native pastures that have been cultivated, fertilised and oversown with Italian ryegrass (*Lolium multiflorum*) and sometimes white clover (*Trifolium repens*). However, the rate of fertiliser applied at pasture establishment was generally low and no subsequent maintenance fertiliser and/or oversowing was carried out for many years. The fertilised pastures are different from the native grasses due to a greater presence of ryegrass and white clover. The productivity of the fertilised pastures is believed to be not significantly better than that of the native pastures. This belief is based on the fact that the native pastures do have an amount of improved pasture species and the fertility levels of the 'fertilised' pastures are not significantly higher.

Table 5: Composition of the native pastures in terms of grasses and legumes species in summer on the predominant soil types for the Brazilian case farm.

Species	Bage	Acegua
Grasses		
Axonupus affinis	5 [2]	4
Paspalum notatum	5	5
Paspalum dilatatum	5	5
Paspalum plicatulum	4	3
Panicum demissum	3	4
Legumes		
Desmodium incanum	2	4
Galactia marginalis	4	0

Source: Goncalves et al. (1988).
[2]The rate of occurrence is an scale: 0 = not present, 1 = very rare, 2 = rare, 3 = average, 4 = frequent, 5 = very frequent (Oosting, 1951).

Table 6: Winter grasses occurrent in the native pastures of the predominant soil types for the Brazilian case farm.

Species	Bage	Acegua
Grasses		
Lolium multiflorum	4 [2]	0
Piptochaetium montevidensis	3	2
Phalaris angusta	4	1
Stipa neesiana	4	3
Stipa papposa	4	0
Stipa charruana	5	0
Legumes		
Adesmia bicolor	4	4
Adesmia securigerifolia	4	3
Medicago polimorpha	5	4
Trifolium polymorphum	4	5
Trifolium dubium	4	0

Source: Goncalves et al. (1988).
[2]See Table 5 for definition of scale units.

Improved pastures are those pastures with a high presence of ryegrass, white clover and birdsfoot trefoil (*Lotus sp.*). These areas have higher fertility levels due to the application of more fertiliser on pasture establishment and subsequent regular maintenance fertiliser applications. These pastures are of higher quality for animal production and produce more dry matter annually than the native and 'fertilised' pastures.

Pastures have been established on the irrigated rice area. This area will return to rice cultivation in 2 to 4 years. The establishment of pasture in this area is generally by oversowing ryegrass and sometimes white clover. Fertiliser rates are low, if any, and pasture establishment is generally poor. Some of these pastures produce as much as an improved pasture in their first year. After the first year the presence of ryegrass and clover decreases and production is similar to that of native pastures. However, rice prices are depressed at present and the 760 ha of 1995 irrigated rice crop are being developed into improved pasture, with higher rates of fertiliser, to improve beef cattle revenue.

Sorghum is cultivated for grain and silage for cattle during periods of pasture shortage or to supplement their diet when a high energy intake is needed. The sorghum crop is sometimes used to renew the improved pastures where ryegrass and white clover persistence is poor. This method of pasture establishment is by cultivation with appropriate rates of fertiliser.

Cultivated forest areas comprise eucalyptus trees planted for shade for cattle during the summer months. There is no commercial interest in felling trees because the city of Bage is poorly developed with a low timber demand and transport to the bigger cities is expensive. The wood from the trees is used for cooking and heating on the farm. The native forests in this region occur in the form of small bush areas along the river banks. These trees are protected by law and are not used for any purpose on the farm.

The dam area comprises three dams to supply water to irrigate rice crops. One of these dams is in the leased area. Together the three dams can accumulate 12,200,000 m^3 of water. The 40 ha of swamp area may be used for grazing during the summer months.

3.1.5. Fertiliser policy

Fertiliser is applied to the irrigated rice crop and sorghum areas on the basis of soil chemical analysis and the recommendations for the crop. Areas of improved pastures receive 9 kg of phosphate (P) per ha/y unless cash shortages prevent this action. Areas of native pasture never receive fertiliser application, and areas of 'fertilised' pastures receive 9 kg of P/ha at establishment but are rarely fertilised in the following years.

3.1.6. Animal production

The main animal production enterprise on the farm is beef cattle. Beef cattle numbers for a status quo year are presented in Table 7.

Table 7: Beef cattle stock reconciliation for a status quo year on the Brazilian case farm.

Categories	Initial (July)	Natural increase	Net Sales	Deaths	Final (June)
Calves		1349		54	
R1Hfrs	648		227	6	648
R2Hfrs	414		130	21	414
R3Hfrs	263		0	13	263
Cows	1000		200	50	1000
R1Steers	324		0	3	324
R2Steers	321		305	15	321
R1Bulls	324		306	16	324
R2 Bulls	14		0	1	14
B'dg Bulls	50		10	3	50
Total	**3358**				**3358**

Source: Martins, 1996 (pers. comm.).

The farm produces its own steers and replacement heifers. On average, 20% of the cows are replaced each year. Heifers not needed for herd replacements are sold. Some heifers (38%) get in calf at 14 to 15 months of age (R2Hfrs), but those that are less than 280 kg liveweight at 14 months are not mated until 26 months of age. The herd calving percentage is around 95%.

Male calves are selected to be used as breeding bulls according to their expected breeding value (EBV). In the selection process 50% of the male calves are castrated at weaning and another 25% are discarded at 12 months of age. The remaining 25% are kept and sold as commercial breeding bulls.

Other stock on the farm, include working horses and sheep for home meat consumption and wool production (Table 8).

Table 8: Breeding and working horses and sheep stock reconciliations for a status quo year for the Brazilian case farm.

Categories	Initial (July)	Natural increase	Net Sales	Death	Final (June)
Colt		39	3	2	
R1 female	17		1	1	17
R2 female	15			1	15
Mare	47		13	1	47
R1 male	17		1	1	17
R2 male	15		14	1	15
Stallion	10				10
Working horses	32				32
Other horses	55				55
Total horses	**208**				
Lambs		1120	740	56	
R1 female	292		45	15	292
Sheep	887		187	45	887
R1 male	32		30	2	32
Ram	9				9
Total sheep	**1220**				

Source: Martins, 1996 (pers. comm.).

3.1.7. Crop production

Irrigated rice is cultivated under a share cropping agreement. The farmer receives a fixed percentage of the production depending on the contract (Table 9). In one form of the contract the farmer provides water, land and part of the financial capital and receives 50% of the production. In another form, the farmer provides land and water and receives 20% of the production, and with a third contract type the farmer provides just the land and receives 10% of the production.

Table 9: Rice crop areas and contracts for a steady state year for the Brazilian case farm.

Contract	Area (ha)	% to the farmer	Rice expected to be received (tons)	Farmer's capital
Lease 1	418	50%	1,035	Land, water and finance
Lease 2	131	19%	123.2	Land and water
Lease 3	46	10%	22.5	Land
Total	**595**		**1,180.7**	

Source: Martins, 1996 (pers. comm.).

3.1.8. Financial details

Cash inflows and outflows for both the Brazilian and New Zealand case farm are presented in the format used by the New Zealand Meat and Wool Board Economic Service. Details of cattle sales and income are presented separately in Table 10. Cash inflows related to irrigated rice, horses, sheep meat and wool are presented in Table 10 as "other" farm income.

Table 10: Farm income for a status quo year based on prices for the 1995/1996 season for the Brazilian case farm.

Cattle Sales	Number	Value (NZ$)
R1 Hfrs	227	57,695
R2 Hfrs	130	53,118
Cows	200	59,640
R2 Steers	305	171,038
R1 Bulls	306	97,571
B.Bulls	10	11,309
Other farm income		337,342
Total source of funds		**787,713**

Source: Martins, 1996 (pers. comm.).

Farm expenditure is also presented for the July 1995 to June 1996 financial year in the format used by the New Zealand Meat and Wool Board Economic Service (Table 11). The major expenses are wages and administration. Wages of three office personnel are included under administration. "Other" expenses comprise all shearing costs, and technical assistance, and expenses not included under a specific heading. Rent is the annual payment made for the 1002 ha leased land. The Brazilian case farm application of funds is presented in Table 12. The total farm debt in June 1996 was NZ$ 170,000.

Table 11: Farm business expenditure for the Brazilian case farm.

Item	Value NZ$
Working expenses	
Wages	177,257
Administration	137,588
Animal health	46,198
Contract	7,827
Electricity	6,021
Feed and grazing	6,874
Fertiliser	20,264
Freight	7,410
Fuel	22,295
Lime	0
Repairs and maintenance	26,228
Seeds	4,582
Vehicles	10,357
Weed and pest control	165
Other expenses	58,248
Sub total	**531,314**
Standing charges	
Insurance and ACC Levy	0
Rates	28,707
Managerial salaries	0
Interest	0
Rent	28,642
Total farm cash expenditure	**588,663**
Farm cash surplus	**199,050**
Depreciation	70,000

Source: Martins, 1996 (pers. comm.).

Table 12: Brazilian case farm applications of funds.

Applications of funds	Value (NZ$)
Plant and vehicles	70,000
Drawings	73,500
Tax	32,262
Interest net of tax	14,160
Principal repayment	9,127
Total	**199,050**

Source: Martins, 1996 (pers. comm.).

3.2. New Zealand case farm description:

3.2.1. Location

The New Zealand sheep and beef case farm is located in the south-west of the North Island (between 39° 30' and 40° south of the Equator and between 174° 30' and 175° East of Greenwich) in the Wanganui region and, more specifically, in the Waitotara county (Figure 2).

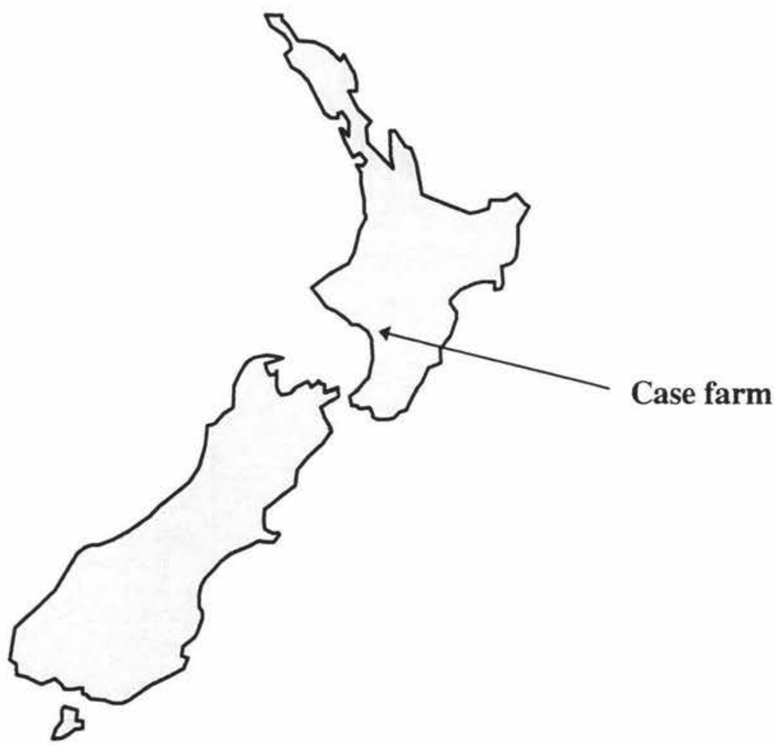

Figure 2: New Zealand map showing the location of the case farm.

3.2.2. Climate

The average rainfall is 860 mm pa. and it is spread fairly evenly through the year with maximum monthly total in early winter and minimum in autumn. Monthly rainfall is usually adequate for pasture growth, except in the summer when a water deficit is often a limiting factor. The case farm is situated near the coast and has a lower rainfall than inland Wanganui. In 25 to 30% of years, dry conditions are expected to last for two consecutive months and rarely for three consecutive months.

The range of air temperatures is small; not often going over 27 °C in summer or below 0 °C in winter. Ground frosts are expected on 12 days per year and snow and hail occur rarely.

3.2.3. Soil types and natural chemical fertility

The soil types on the farm are broadly called "Sand Country". These soils are drought prone and, if they are devoid of vegetation, the sand is prone to drifting. The soils being developed are on flat sand plains and comprise yellow-brown sand. They are free draining, of low to medium natural fertility and have the potential for minor wind erosion. The potential carrying capacity of these soils is 20 stock units per hectare (SU/ha) if they are fully developed and 9 SU/ha in their undeveloped state (Keating, 1979). These soils also have a good growing potential for forestry.

3.2.4. Area and pastures

Land use areas on the farm are shown in Table 13. The area being developed comprises 247.4 ha of yellow-brown sand. This offers the potential to almost double present pasture and animal production through fertiliser inputs and oversowing with more productive and better quality pasture species. The new farm comprises an area of 1452 ha adjacent to the home farm bought in 1993. The analysis of the partial development of the latter, is the subject of this thesis.

Table 13: Total area divided by land use for the New Zealand case farm.

Description	Area (ha)
Effective pasture area (home farm)	1049
Pasture being developed (new farm)	49
Pasture to develop (new farm)	247
Areas of lower potential (new farm)	910
Asparagus crop	15
Pine trees	307
Waste area	21
Total effective pasture area	2255
Total home farm area	1146
Total new farm area	1452
Total area	**2598**

Source: Pearse, 1996 (pers. comm.).

3.2.5. Fertiliser policy

Pasture on the home farm is topdressed with a maintenance rate of fertiliser (30 kg P/ha). These areas are already have improved pastures and are intensively used. Areas on the new farm undergoing development receive an initial rate of 118 kg P/ha and are thereafter annually top dressed with 40 to 45 kg P/ha. The areas of lower potential receive a lower annual dressing of 24 kg of P/ha because of their lower pasture production and utilisation.

The impact of the present fertiliser policy can be seen in the change in Olsen P levels (Table 14) for three paddocks at different stages of development. The initial levels of P in 1992 have increased for all paddocks. The "Sigma" paddock is classified as an area of lower potential and is not included in the plan for cultivation and oversowing with more productive pasture species. "Brittany" is in the area to be developed into new pasture and "Delta" was developed and sown down in new pastures during the winter of 1995.

Table 14: Levels of P (ppm) in the soil tests of three paddocks for the New Zealand case-farm.

Soil test dates	Sigma	Brittany	Delta
14/10/92	11	8	11
23/11/93	13	-	7
01/09/95	18	19	20

Source: Pearse, 1996 (pers. comm.).

3.2.6. Animal production

The beef cattle stock reconciliation for the case farm is presented in Table 15 and sheep stock reconciliation in Table 16.

Table 15: Beef cattle stock reconciliation for a status quo year for the New Zealand case farm:

Categories	Initial (July)	Natural increase	Sales net of purchases	Deaths	Final (June)
Calves		598		3	
R1Hfrs	296		206	15	296
R2Hfrs	75		70	5	75
Replacement Hfrs	0		-133	0	0
Cows	665		106	27	665
R1Steers	296		-207	3	296
R2Steers	500		298	10	500
R3Steers	192		188	4	192
Breeding Bulls	19		-1	1	19
Total cattle	**2043**				**2043**

Source: Pearse, 1996 (pers. comm.).

The farm buys in around 40% of the steers it finishes and produces the other 60% from the Angus crossbred herd of 665 cows. All heifers produced on the farm are sold and replacement crossbred heifers are bought in. On average, 20% of the cows are replaced each year. The calving percentage is around 90%.

Table 16: Sheep stock reconciliation for a status quo year for the New Zealand case farm.

Categories	Initial (July)	Natural increase	Net Sales	Deaths	Final (June)
Lambs		9950	6600	300	
Ewe hoggets	2350		0	150	2350
Ewe two tooths	2200		0	150	2200
Ewes	5400		1996	54	5400
Ram hoggets	60		24	4	60
Ram two tooths	34		15	2	34
Rams	82		12	5	82
Total sheep	**10126**				**10126**

Source: Pearse, 1996 (pers. comm.).

The farm sells all male lambs and half of the female lambs are kept for flock replacements. Shearing occurs once every 8 months so that the flock is shorn three times every two years. The lambing percentage is around 130%.

3.2.7. Crop production and shell rock mining

Asparagus is cultivated every year on the farm. An area of 15.10 ha has provided the farmer with a stable gross income of around NZ$ 183,000 per annum for the last four years. The farmer's objective is to keep on cropping asparagus. Shell rock is another source of income for the farm, it is expected to generate NZ$ 6,000 per year.

3.2.8. Financial details

Cattle sales are presented for the 1995/96 and previous season in Table 17. Details of the previous season's beef cattle income are also shown to highlight the impact of the crash in the beef prices on the 1995/96 farm income. Other farm income includes asparagus sales and wool, lamb and sheep sales.

Table 17: Farm income for a status quo year (based on costs and prices for the 1995/1996 season) and for the previous season for the New Zealand case farm.

Cattle Sales	Season 1995/96 (NZ$)	Previous season (NZ$)
R2 Hfrs	57742	115485
R3 Hfrs	21317	42635
Cows	(7199)	(14397)
R2 Steers	(40559)	(81118)
R3 Steers	276489	552978
B.Bulls	(6439)	(12879)
Other farm income	593102	593102
Total	**849467**	**1195806**

Source: Pearse, 1996 (pers. comm.).

The farm's expenditure is presented in Table 18. The major expense categories are wages and fertiliser. 'Other' expenses comprises those associated with the asparagus crop, sheep production activities and expenses not listed under a specific heading. Rent is the annual payment for leased land.

Sources and the application of funds for the New Zealand case farm are presented in Table 19. The values are presented with prices of cattle for the 1995/96 and the previous season.

The level of debt at the start of the 1995/96 season was NZ$ 1,750,000. As presented in the Table 19, income from the farm during 1995/96 was insufficient to cover farm expenditure and debt servicing. As a consequence, the farmer had to borrow more to balance the accounts. If the previous season's prices had applied the farmer would have been able to pay all costs and part of the principal on the mortgage.

Table 18: Farm expenditures for the financial year 1995/96 for the New Zealand case farm.

Working Expenses	Value NZ$
Working expenses	
Wages	230000
Administration	15244
Animal health	50000
Contract	0
Electricity	3510
Feed and grazing	21413
Fertiliser	110000
Freight	5187
Fuel	12223
Lime	0
Repairs and maintenance	80000
Seeds	0
Vehicles	16501
Weed and pest control	20000
Other expenses	195750
Sub-total	**759828**
Standing charges	
Insurance and ACC Levy	0
Rates	37929
Managerial salaries	0
Interest	0
Rent	19722
Total farm cash expenditure	**817479**
Farm cash surplus	**76988**
Depreciation	40405

Source: Pearse, 1996 (pers. comm.).

Table 19: New Zealand case farm source and application of funds for the New Zealand case farm.

Farm funds	Season 1995/96 (NZ$)	Previous season (NZ$)
Source of funds		
Farm cash surplus	76988	385551
Non-farm income	45000	45000
Shell rock	6000	6000
Borrowing	42213	0
Sub-total	**170200**	**436551**
Applications of funds		
Plant and vehicles	40405	40405
Drawings	40000	40000
Tax	9146	86287
Interest net of tax payment	80650	78750
Principal payment	0	191110
Sub-total	**170200**	**436551**
Balance	0	0

Source: Pearse, 1996 (pers. comm.).

3.3. Summary/conclusion:

The Brazilian and New Zealand case farm have areas with potential for pasture development to improve animal production and financial results. The farms are subjected to different climate and financial situations, and economic environments. In the next chapter the model built to analyse of the development of both farms is presented.

Chapter Four: Model Description

4.0. Introduction:

In this chapter the components, structure and function of the computer model is presented. Diagrams are used to schematically show information flows in the model and the function of inputs. Each input is described separately in terms of the data needed and the way that it is used in the model.

4.1. General overview of model:

4.1.1. Technical aspects

The model runs in Microsoft Excel and comprises three files. The first file 'Plan.xls', the main component of the model, is where all data are entered and where simulations can be run. The second file, 'Ssim.xls', is used to create and run 'fast' simulations from the data in the 'Plan.xls' file. The third file, 'Stoch.xls', is used to create and run stochastic simulations using the @Risk software (Purvis et al, 1995; Patrick and DeVuyst, 1995), an 'add-in' to Microsoft Excel.

4.1.2. Model outline

The model simulates the physical and financial results of implementing a pasture development programme on a pastoral beef cattle farm. It could easily be modified to include other classes of livestock, but as the model's primary application will be to cattle-only farms in Southern Brazil it was not necessary to include a multi-species capacity for this study. The model outline with the different templates and information flow is shown in Figure 3. Input variables and

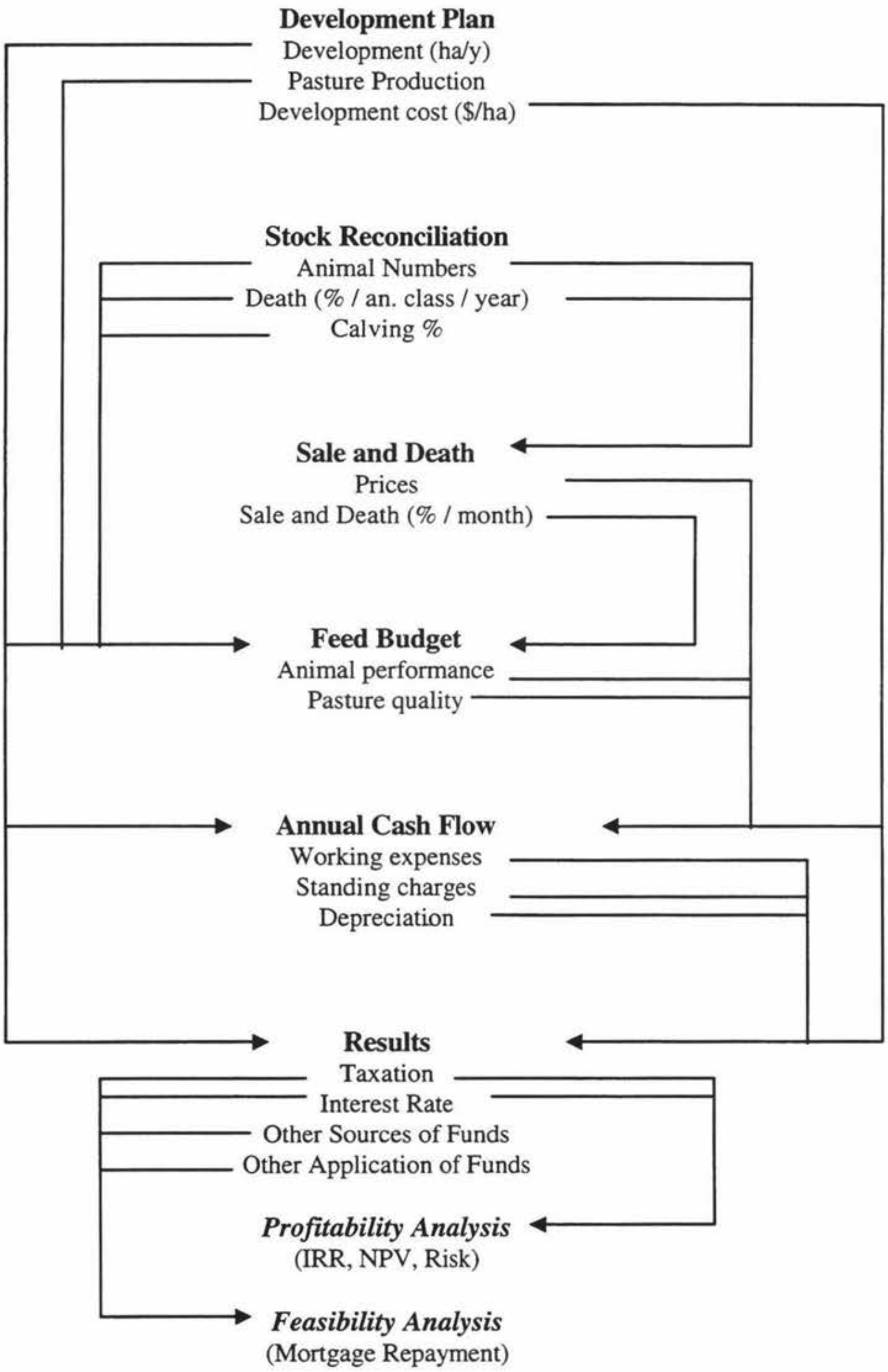

Figure 3: Schematic outline of model components and direction of data flows.

their uses in the model are shown in Appendix I and Appendix II, respectively. Pasture is assumed to be developed from a 'native' to an 'improved' state. The model simulates how many extra cattle the farm can support every year based on the rate of development and the extra pasture grown and its quality. These changes are reflected in the number of animals sold and bought. Changes in cattle sales are reflected on the farm annual cash flow. The profitability of the development option is calculated by the net present value (NPV) of the discounted annual cash balances and the salvage value of the project. The feasibility of a development option is reflected by the increase and decrease in the size of mortgage held by the business. Risk is measured as the stochastic dominance of one option over the other using stochastic variables for cattle price and production.

4.2. Development Plan template:

The first screen of the model (Figure 4) is designed to specify the pasture development parameters and the farm itself. Pasture parameters are entered directly through this screen. Information about livestock and financial parameters (eg. farm expenditure, mortgage initial balance and interest) are entered through buttons with a macro language that takes the user to the input table for these variables. The data entered in the Development Plan template is explained in detail in the following sections.

Development Plan

Crop Area	0
New Pasture Area (ha/y)	0
Native Pasture Area (ha)	1157
Development Cost ($/ha)	837.28
Pasture in Year 1(ha)	7.3
Pasture in Year 2 (ha)	41.4
Improved Pasture (ha)	1048.92
Total Pasture area (ha)	2255
Stocking Rate increase	0.00%
Total Project NPV	0
Pasture to develop (ha)	247.4

Month	Native Pasture Production Actual	New Pasture Production Year 1	Year 2	Improved
Jul	10	10	21	21
Aug	12.5	12.5	32	32
Sep	21	21	53.5	53.5
Oct	30.5	30.5	56	56
Nov	34.5	34.5	60	60
Dec	31	31	55.5	55.5
Jan	18.5	12	38	38
Feb	18.5	0	0	39
Mar	24.5	0	0	51.5
Apr	23	32.3	32.3	48.5
May	16.5	23.6	23.6	35.5
Jun	11	16	16	24
Total	7652	6822	11863	15647

Figure 4: Development plan template in the farm development model.

4.2.1. New pasture area (ha/y)

The area of pasture to be improved per year (r) is specified in hectares. This is one of the main drivers of the pasture development program. The amount of pasture developed in each year of the development program (χ_j) is dependent on (r) but limited by the total area available for improvement (PD) (Equation 2 and Equation 3), so that when all of the area to be improved has been developed, the value of new pasture area for that year (χ_j) becomes zero (Equation 4).

$$\chi_j = r$$ **Equation 2**

Provided:

$$PD - \sum_{n=0}^{j-1} \chi_n > r$$

$$\chi_j = PD - \sum_{n=0}^{j-1} \chi_n$$ **Equation 3**

Provided:

$$0 < PD - \sum_{n=0}^{j-1} \chi_n < r$$

$$\chi_j = 0$$ **Equation 4**

Provided:

$$PD - \sum_{n=0}^{j-1} \chi_n = 0$$

Where:

r = new pasture area (ha/y);
χ_j = pasture to develop in the j^{th} year (ha);
PD = total pasture to develop (ha).

The value of the improved pasture area (A_{ij3}) will increase year by year (Equation 8), decreasing the amount of native pasture (A_{ij0}) (Equation 5, Equation 6 and Equation 7) until all the area to be developed (PD) is finished. The amount of pasture developed every year will increase farm pasture production (PP_{ij}) (Equation 9). For pasture quality the same approach is used.

$$A_{j0} = A_{(j-1)0} - \chi_{j-1}$$ **Equation 5**

$$A_{j1} = \chi_{j-1}$$ **Equation 6**

$$A_{j2} = A_{(j-1)1}$$ **Equation 7**

$$A_{j3} = A_{(j-1)3} + A_{(j-1)2}$$ **Equation 8**

$$PP_{ij} = \frac{\sum_{k=0}^{3} (A_{jk} x Y_{ik})}{\sum_{k=0}^{3} A_{jk}}$$ **Equation 9**

Where:

PP_{ij} = weighted average pasture production in the i^{th} month of the j^{th} year (kg DM/ha);
A_{jk} = pasture area in the i^{th} month of the j^{th} year and k^{th} category (ha);
Y_{ik}= pasture production in the i^{th} month for the k^{th} category (kg DM/ha);
k=0 = native pasture;
k=1 = pasture in year 1 of development;
k=2 = pasture in year 2 of development;
k=3 = improved pasture.

Some farm expenditure will increase in conjunction with an increase in the area of improved pasture. For example, more fertiliser will be used on the improved pasture areas then on the previous native pasture. The extra inputs are entered as a percentage increase relative to the new pasture area (χ_i), as discussed further in the Annual Cash Flow template section. In a similar fashion, the amount of money invested in development each year is dependent on the area developed into new pasture and the development costs per hectare. The development project thus influence the farm's Annual Cash Flow, and the Profitability and Feasibility Analysis.

4.2.2. Native pasture area (k=0)

Native pasture represents the total undeveloped pasture area (ha) of the farm. It is called 'native' because this is the state of the undeveloped pastures in southern Brazil, but it could represent any pasture that is in a less developed state than the farm manager desires (eg. a 50 year old pasture established by oversowing on a bush burn in New Zealand). The area of native pasture multiplied by its respective monthly production gives the total amount of pasture produced per hectare on the native area. This value is combined with the amount of pasture produced per hectare on the other areas of the farm in order to calculate average farm pasture production in each month of the year (Equation 9).

4.2.3. Pasture development cost (NZ$/ha)

The pasture development cost is the expense of transforming the pasture from an undeveloped to a developed state. It is entered as a single value per hectare. The amount of money spent on developing each hectare into new pasture will influence the farm's Annual Cash Flow as stated before.

4.2.4. Pasture in year 1 of development (k=1)

Pasture in year 1 is the area (ha) of pasture in the first year of the development in a given year. If an area of 25 ha is going to be developed in $Year_j$ these 25 ha are considered as 'Pasture in year 1 of development (k=1)'. Next year, $Year_{j+1}$, this pasture is considered as 'Pasture in year 2 of development (k=2)'. In the following year, $Year_{j+2}$, this pasture is considered to have reached its full production potential and is classified as 'Improved pasture (k=3)' (Equations 5, 6, 7 and 8).

4.2.5. Pasture in year 2 (k=2)

Pasture in year 2, as explained above, is the area of pasture in the second year of development. This area of pasture has not yet reached its full production potential.

4.2.6. Improved pasture (k=3)

Improved pasture is the area (ha) of pasture that has reached its full potential in pasture production and quality, and will maintain these production levels with appropriate management. The increase in the improved pasture area results in more kg of better quality dry matter (DM) being produced on the farm. The quality of the pasture is measured as energy per kg DM (MJ ME/kg DM).

4.2.7. Pasture to develop (PD)

Pasture to develop is the area of native pasture that is going to be developed during the development program. This value may be the same as the native pasture area ($A_{k=0}$) or less, as for the New Zealand case farm where just 274 ha of the 1157 ha of native pasture are being developed. The project stabilises when all of the area to be developed is in full production.

4.2.8. Pasture production (Y_{ik})

Pasture production is entered as kg of DM/ha in the i^{th} month for the different k^{th} pasture development categories in a table in the Development Plan template (Figure 4). The sum of the total pasture production for the year for each pasture class appears in the bottom of the table just for verification. The data for pasture production in each month of the year are used together with the amount of area in that class in each year of the development plan to determine the average monthly pasture production for the farm (PP_{ij}) (Equation 9).

4.3. Stock Reconciliation template:

The 'Stock Reconciliation' template is designed to enter the number of animals wintered on the farm, the calving percentage (%), animal losses (%), the percentage (%) of cows and bulls replaced per year, and the percentage of stock (in stock units) other than beef cattle on the farm. The numbers entered in this template (Figure 5) are used to calculate a status quo stock reconciliation for the farm. The status quo stock reconciliation calculates the net sales and deaths of animals in each animal class. Net sales are used with schedule prices to determine the gross cattle revenue. The inputs for the stock reconciliation template are explained in the following sections.

	Enter Animal Data				
	Stock	Losses	Calving	Males left	Other Stock
Status Quo	Numbers	Killed (%)	(%)	Entire (%)	(%) SU
Hfr Calves		4%	95%	50%	20%
Rising 1yr Hfrs	648	1%		R1Hfrs mated %	
Rising 2yr Hfrs	414	5%		38%	
Rising 3yr Hfrs	263	5%	Replacement %		
Breeding cows	1000	5%	25%		
Dry cows/heifers	0	5%			
Weaners steers		4%			
Rising 1yr Steers	324	1%			
Rising 2yr Steers	321	5%			
3yr and older	0	5%			
Bulls					
Calves		4%			
Rising 1yr Bulls	324	1%			
Rising 2yr Bulls	14	5%			
3yr and older	0	5%	Replacement %		
Breeding bulls	50	5%	25%		

Figure 5: 'Stock Reconciliation' template illustrating the input data for preparing a beef cattle stock reconciliation.

When the model is run, the percentage change in stocking rate, that results from development, makes commensurate adjustments in animal sales each year. Between year changes in livestock numbers are achieved by decreasing sales or increasing purchases to raise the stocking rate (Equation 11), based on the amount of pasture eaten in a status quo situation (Equation 10). It was necessary to stabilise the first year's feed budget of the farm with a constant (α) because no pasture growth measurement data were available. The Grow model (Butler, 1994) was used to generate the data required. The same constant was retained to equilibrate the feed demand and supply during the development program. The pasture eaten by the animals was significantly lower than the pasture production predicted by the Grow model.

In addition, in a more sophisticated model it would be prudent to adjust for the effects of within season surplus pasture on feed quality (see, for example McCall, 1984).

The proportion of each animal class on the farm is kept constant over time. The number of animals in each animal class in a given year increases/decreases on the basis of the same percentage value. The percentage increase in stocking rate for the year is dependent on how much more pasture production is expected for that year. The increase in the year's stock numbers can only be achieved by buying, or not selling, animals in the current year. The change in stock numbers will influence the cash flow and in this respect closely resembles the feed profile for each year.

$$\frac{N_0 x C_0}{PP_0 x A_0} = \alpha$$ **Equation 10**

$$N_j = \frac{\alpha(PP_j x A_j)}{C_j}$$ **Equation 11**

Where:

N_j = Number of animals in the j^{th} year;
C_j = Animal consumption in the j^{th} year (kg DM/animal);
j=0 = Status quo situation of the farm (before development);
α = percentage of pasture eaten by stock;
$PP_j = \sum_{i=1}^{12} PP_{ij}$;
$A_j = \sum_{k=0}^{3} A_{jk}$.

4.3.1. Stock numbers (S_j)

The number of animals in each animal class on the farm on 1 July of the first year of the development project are entered in this template.

4.3.2. Losses and killed (%)

The values entered under losses and killed are the percentage of animals lost and killed in each animal class during each year. The percentage is expressed relative to the number of animals wintered (i.e. 1 July). This number is used to calculate the Stock Reconciliation as stated before. The percentage values are fixed for the whole project. Thus, the absolute number of animals lost and killed increases axiomatically with the number of animals on the farm.

4.3.3. Calving (%)

Calving percentage is expressed as the ratio of calves born to the number of cows and heifers mated. The number of calves produced is the natural increase of the herd each year. The calves are considered to be 50% males and 50% females. The calving % is considered to be fixed over the whole project.

4.3.4. Males left entire (%)

Males left entire is the percentage of male calves not castrated and sold as bulls or retained on the farm as breeding bulls. The reason for separating these two classes is that feed requirements for the liveweight gain of bulls and steers are different (Mc Rae & Morris, 1984) and accordingly they are considered separately in the feed budget template. Also, bulls and steers have to be treated separately because they may be sold at different times of the year, with different liveweights and for different prices, as is the case for other animal classes.

4.3.5. Other stock (SU%)

Other stock is entered as the percentage of total stock units (SU%) on the farm that are not beef cattle. The model uses this value to allocate part of the pasture produced on the farm to these animals. This is estimated by taking out the proportional amount of the area of improved pasture of the farm in the status quo situation to feed these animals. Any area to be developed is left solely for beef cattle. Consequently, when the model is run extra pasture production and the benefits of improved pasture quality are used to increase the number of beef cattle on the farm. The development results reflect how many more beef cattle the farm can support and the prices the farmer receives for these extra animals. To convert cattle numbers to stock units (SU) the conversion factors shown in Table 20 were used:

Table 20: Stock units conversion factors.

Livestock class	SU conversion factor
Ewe	1
Rams	1
Wether	0.7
Hogget	1
Working horses	8
Mare	10
R1 female horses	4
R2 female horses	6
R1 male horses	4
R2 male horses	6

Source: Cornforth & Sinclair, 1984

The emphasis on cattle was adopted because farms in southern Brazil normally have beef cattle as the only commercial stock on the farm. In New Zealand, beef cattle are usually farmed together with sheep (and/or deer) in a mixed enterprise 'sheep and beef cattle farm'. The proportion of beef and sheep vary depending on the farm's resources and farmer's objectives.

The proportion of sheep and beef cattle on a New Zealand farm tend to change over time in response to their relative gross margins and the circumstances of the farmer (e.g. age, availability of labour). A further development of this model would therefore be to include a separate feed budget, and stock reconciliation, and prices for sheep so that the proportion of sheep and beef cattle on the farm could be altered as development progressed.

4.3.6. Replacement (%)

The percentage value of animals replaced each year is entered for both breeding cows and breeding bulls. These percentages are used to calculate the number of heifers that need to be retained and the number of bulls that need to be purchased each year. The value influences the number of heifers that can be sold. The percentage value of replacements is fixed for the whole project.

4.3.7. R1Hfrs mated (%)

The percentage of heifers mated at 14 to 15 months of age, to calve at 23 to 24 months of age, are entered in the 'R1Hfrs mated' cell. This value is fixed over the whole project, although the increase in pasture production and quality could be used to justify an increase in the percentage of heifers being mated at this age because it is likely that more heifers would reach the critical target mating liveweight than in an undeveloped situation. This is not the case in this model because the model was not designed to predict changes in livestock performance. Rather the model keeps individual animal performance constant and utilises extra feed by increasing the number of animals on the farm.

4.4. Sale and Death template:

The Sale and Death template is designed as an input format for entering the percentage of animals sold and killed or lost in each month of the year for each animal class (Figure 6). These inputs determine the number of animals sold in each month. Monthly adjustments in stock numbers are incorporated in the feed budget and are reflected by decreased numbers of animals in each month. Animals can be sold store (per head) or finished (per kg of carcass weight). In this template the selling option for each category of animals is entered. The prices for store and finished animals are also entered for each month of the year and for each animal class. To account for the taxation implications of changes in cattle numbers, prices for the herd scheme are entered into this template as well. The inputs for the Sale and Death template are explained in the following sections.

Sale Pattern	Pred.	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Hfr Calves	100												100	100
R1yr Hfrs	100									100				100
R2yr Hfrs	100									100				100
R3yr Hfrs	100												100	100
Cows	100											100		100
Dry cows/heifers	100												100	100
Weaners steers	100												100	100
R1yr Steers	100			100										100
R2yr Steers	100			-37					137					100
R3yr and older	100								100					100
Bull Calves	100												100	100
R1yr Bulls	100			100										100
R2yr Bulls	100								100					100
R3yr and older	100								100					100
Breeding bulls	100			-113					100					-13
Death/Kill														
Hfr Calves	100			10	10	10	10	10	10	10	10	10	10	100
R1yr Hfrs	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R2yr Hfrs	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R3yr Hfrs	100	8	8	8	8	8	8	8	8	8	8	8	8	100
Cows	100	2	2	40	25	20	2	2	2	2	2	2	2	100
Dry cows/heifers	100	8	8	8	8	8	8	8	8	8	8	8	8	100
Weaners steers	100			10	10	10	10	10	10	10	10	10	10	100
R1yr Steers	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R2yr Steers	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R3yr and older	100	8	8	8	8	8	8	8	8	8	8	8	8	100
Bull Calves	100			10	10	10	10	10	10	10	10	10	10	100
R1yr Bulls	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R2yr Bulls	100	8	8	8	8	8	8	8	8	8	8	8	8	100
R3yr and older	100	8	8	8	8	8	8	8	8	8	8	8	8	100
Breeding bulls	100	8	8	8	8	8	8	8	8	8	8	8	8	100

Figure 6: Sale and death pattern template.

4.4.1. Sale pattern

The percentage of animals sold in each month of the year in each animal class is entered in the sale pattern template (Figure 6). These data will, together with the stock reconciliation for the year, determine the number of animals sold in each month of the year. While the sale pattern is assumed to be maintained throughout the years of the project, the number of animals sold each month is influenced by the increase and decrease in livestock on the farm. The animals sold each month are automatically deducted from their respective feeding group in the feed budget. If animals are bought onto the farm a negative value needs to be entered as a percentage of the sales within the animal class concerned.

4.4.2. Death pattern

The percentage of animals lost or killed each month for each animal class is entered in the death pattern template (Figure 6). The default value is that the animals die in the same proportions throughout the year (i.e. the number of deaths in any month of the year = 100% /12 months x the number of animals in $class_q$ at $month_i$). This value links back to the feed budget and decreases the number of animals in each animal class. Variation in the death pattern is not expected to have a large influence on the feed budget due to the small numbers of animals that are expected to die during the year.

4.4.3. Sale option

The two options for sale of animals are "store" or "finished". The sale option is entered by entering 's' for store and 'f' for finished for each animal class. The sale option is maintained for the nominated animal class for the duration of the project. If animals in the same class are bought store and sold finished in the same year, the finished option should be chosen. The purchase price should, in this case, be adjusted for carcass weight in the respective month of sale.

4.4.4. Prices

The prices at sale are entered by month and for each animal class. Seasonality in prices received reflect the local circumstances. In countries dependent almost exclusively on an internal market, such as Brazil, monthly prices may be required to reflect the meat production pattern. In contrast, where prices are heavily dependent on export markets, such as in New Zealand, the schedule may more closely reflect the mixed influence of pasture availability, market prices and the exchange rate. Monthly entries allow different patterns of cattle prices to be simulated. Prices are entered for both store and finished animals.

4.4.5. Dressing out %

The dressing out percentage is the relationship between the liveweight of the animal and carcass weight. This is an important economic parameter when animals are sold for slaughter under the 'finished' sale option. For this sale option, the prices are expressed per kg of carcass. This means the average liveweights from the feed budget template are automatically transformed to a carcass weight equivalent for use in the financial model.

4.4.6. Herd scheme prices

The prices of the Herd Scheme are entered to value the animals, at the end of the financial year, that are not sold during the period the farm is increasing stock numbers. These values are used in the 'Profit and feasibility template' (Section 4.7) to calculate the tax liability and the post-tax farm cash surplus.

4.5. Feed Budget template:

The feed budget template is designed to calculate the feed demand and supply for the case farm. Performance in terms of liveweight gain is entered for each month of the year and animal class and pasture quality values are entered per month (Figure 7). Animal numbers are entered automatically by combining the data from the stock reconciliation, and sale and death templates. The animal performance and pasture quality parameters are utilised to predict animal intake and the total quantity of pasture consumed. The different classes of stock may lose or gain weight during the year. The template calculates and displays the average liveweight for the respective animal classes in each month of the year (Figure 7). The only inputs required for the feed budget template are animal performance and pasture quality.

Cows	665	665	664	653	647	642	641	641	640	640	639	532
Intake/head/day	12.7	14.2	7.0	6.4	7.1	8.1	9.0	7.4	4.3	3.9	7.4	8.7
Initial liveweight	380	411	440	418	402	387	372	364	357	349	349	365
Liveweight gain/day	1	1	-0.75	-0.5	-0.5	-0.5	-0.25	-0.25	-0.25	0	0.5	0.5
End liveweight	411	442	418	402	387	372	364	357	349	349	365	380
R1yr Steers	296	296										
Intake/head/day	3.6	3.6										
Initial liveweight	179	195										
Liveweight gain/day	0.5	0.5										
End liveweight	195	210										
R2yr Steers	500	499	296	503	503	503	503	502	502	502	502	501
Intake/head/day	8.5	8.5	4.6	6.1	7.9	8.8	9.0	8.0	10.3	8.1	9.0	7.7
Initial liveweight	453	469	210	225	256	286	317	341	362	393	415	438
Liveweight gain/day	0.5	0.5	0.5	1	1	1	0.75	0.75	1	0.75	0.75	0.5
End liveweight	469	484	225	256	286	317	341	362	393	415	438	453

Figure 7: Partial view of the feed budget template where animal performance data are entered.

4.5.1. Animal performance

Animal performance is entered in terms of liveweight gain as kg/day for each animal class and in each month of the year, as stated before. It is entered directly in the feed budget so that the user can follow the liveweight of the animals during the year and manipulate the level of animal intake so that a biologically feasible pattern (Marshall et al., 1991) of monthly pasture is achieved. The animal intakes are based on the liveweight of the animals, their liveweight gain and the quality of pasture (Geenty & Rattray, 1987).

4.5.2. Pasture quality

Pasture quality is expressed as megajoules of metabolised energy per kilogram of dry matter (MJ ME/kg DM) for each month of the year for the native pasture and for the improved pasture. The pasture quality values used in the feed budget represent the weighted average of the native and improved pastures (Equation 12). Improvements in pasture quality can influence animal performance. In the case of this model, performance is not predicted but considered to be constant, and as a consequence, any increase in quality results in an increased number of animals that can be feed per kg of DM produced.

$$Q_{ij} = \frac{\sum_{k=0}^{3}(q_{ik} x A_{jk})}{\sum_{k=0}^{3} A_{jk}}$$ **Equation 12**

Where:

Q_{ij} = weighted average of pasture quality for the i^{th} month of the j^{th} year;
q_{ik} = pasture quality for the i^{th} month of the k^{th} class of pasture.

4.6. Annual Cash Flow template:

The annual Cash Flow template calculates the farm's annual cash flow stock sales, derived from previous templates, and the working expenses, standing charges and depreciation that are entered into this template (Figure 8). Working expenses and standing charges can be correlated with the increase in number of stock and the area of improved pasture. The annual cash flow template for the farm calculates gross cattle revenue, and total farm expenditure, and the farm's annual cash surplus. Total farm expenditure increases during the project according to the correlations between the various expenditure categories and their assumed association with stocking rate and the area of improved pasture. The inputs for the Cash Flow template are: working expenses, standing charges, depreciation and correlation factors for expenditure items.

Working Expenses	Value $	Cor. Stocking Rate	Cor. New Pasture
Wages	230000	0%	0%
Administration	15244	0%	0%
Animal Health	50000	80%	0%
Contract	0	0%	0%
Electricity	3510	0%	0%
Feed and Grazing	21413	0%	0%
Fertiliser	110000	0%	75%
Freight	5187	0%	0%
Fuel	12223	0%	0%
Lime	0	0%	0%
Repairs and Maintenan	80000	0%	0%
Seeds	0	0%	0%
Vehicles	16501	0%	0%
Weed & Pest Control	20000	0%	50%
Other expenses	195750	0%	0%
Standing Charges	**Value $**	**Cor. Stocking Rate**	**Cor. New Pasture**
Insurance and ACC Le\	0	0%	0%
Rates	37929	0%	0%
Managerial Salaries	0	0%	0%
Interest	0	0%	0%
Rent	19722	0%	0%
Depreciation	40405		

Figure 8: Input template for farm working expenses, standing charges and depreciation.

4.6.1. Working expenses

Farm working expenses are entered for the status quo situation. They are considered to be constant during the whole project unless the item is positively correlated with an increase in cattle numbers and/or an increase in the area of improved pasture. Working expenses included in the model are explained in the following sections. These categories include the items, and are calculated, as described by Parker (1993).

4.6.2. Standing charges

The standing charges are entered for the status quo situation and, as stated for the working expenses, are considered to be constant unless they are correlated with changes stocking rate and/or pasture improvement. The standing charges used in the model are explained in the following sections.

4.6.3. Depreciation

Depreciation of capital assets of the farm is considered to be a single constant value and is based on a straight line depreciation of the capital assets on the farm. The capital assets of the farm are considered to be replaced at an average cost equal to the yearly value of depreciation, so that depreciation does not change over time. The user needs to evaluate capital assets and calculate the value of depreciation for the status quo. Depreciation on the capital investment made as a consequence of the development project is accounted for in a separate item in the 'Profit and Feasibility' template.

4.6.4. Correlations

All items of farm expenditure and standing charges can be correlated to an increase in improved pasture and/or on increase in stocking rate. For example, if animal health expenditure increases as the stocking rate increases and the correlation is 100%, then if stocking rate in $year_j$ increases by 1%, animal health expenditure increases by 1%. If the farmer can get a better 'bulk' deal for input prices, the correlation may be 80%, meaning that if stocking rate increases by 1% for $year_j$ animal health expenditure will increase by only 0.8% in that year (1.008 x expenditure in $year_{j-1}$). The use of correlation factors for expenditure items eliminates the need to independently enter farm working expenses for each year of the development project.

4.7. Profit and Feasibility template:

The 'Profit and Feasibility' template has two main functions: to perform a profitability analysis on the project, and to estimate the feasibility of the project by accounting for the whole farm system. The analysis uses data entered for previous templates, data entered into this template (Figure 9), and data simulated by the model. The profitability analysis takes into account the project effects in terms of the amount invested and the net present value (NPV) of the difference between the NOPAT (Net Operating Profit After Tax and before Interest) of the project's discounted cash flow and the NOPAT of the continuation of the status quo (i.e. the changes expected due to improvements made in previous years).

The feasibility analysis considers the whole farm business, the debt situation of the farmer, drawings and other non-farm income. The feasibility analysis provides an overview of the predicted farm's financial position in the years to come in terms of the need for extra borrowing and mortgage repayments. The feasibility analysis is specially important in Brazil where the unstable economic situation, to date, has not allowed farmers to take out a significant mortgage. This factor needs to be accounted for when deciding the rate of development (ha/y) for a project. The interest rate charged on the mortgage may in some cases exceed the benefits of the pasture development program, this is reflected in the results of the feasibility analysis. Inputs for the profitability analysis are: other farm income(s), taxation (%), depreciation on the capital investment (%), capital investment (%), and the discount rate factor (%). Inputs for the feasibility analysis are: sources of funds, application of funds, mortgage initial balance and interest rate (%). Definition of these inputs follow.

Enter Data	
Other farm income	593102
Taxation %	25%
Depreciation Capital Investment/year	20%
Capital Investment %	0%
Discount Rate %	6.0%
Farm Source of Funds	
Non-Farm Income	45000
Cash Grants	0
Shell Rock	6000
Application of Funds	
New Buildings & Additions	0
Plant & Vehicles	50000
Income Equalisation	0
Term Deposits	0
Drawings	40000
Other appl. of funds	0
Mortgage	
Initial Balance	1750000
Interest Rate	6.0%

Figure 9: Profit and feasibility input template for the farm development model.

4.7.1. Other farm income

Other farm income is the amount received for farm income earning activities other than beef cattle. This value is considered to be constant over the life of the project. The expense of these activities is accounted for in the farm expenses.

4.7.2. Taxation %

Taxation rate is entered as the percentage value of the farm's profit that has to be paid as tax. The provisional tax is calculated by adding 5% to the previous year's tax payment. Terminal tax paid in $year_{j+1}$ is the difference between the value of provisional tax paid in any one $year_j$ and the actual tax liability of the farmer.

4.7.3. Depreciation on capital investment %

Capital investments included in the development project should be depreciated for tax purposes, but this cannot be deducted in full in the year in which the expense is incurred (Clark, 1996). The percentage value used to depreciate any assets bought during the development project is entered under 'Depreciation on capital investment'.

4.7.4. Capital investment %

The amount of capital investment during the development project is entered as a percentage of the total investment value. It is this amount has that is to be depreciated for tax purposes (Section 4.7.3).

4.7.5. Discount rate %

The discount rate is used to express the difference in NOPAT for each year of the project to a present value. It is used to calculate the post-tax NPV of the project. The discount rate used for the case farm analysis was the real interest rate in 1996 for the respective countries concerned (For more discussion about discount rates see Section 2.8).

4.7.6. Sources of funds

All sources of funds available to the farmer are entered in this section. The farm cash surplus is entered automatically from the data already in the model. Sources of funds from non-farm income and funds not already entered under the heading 'Other farm income', in the profitability section, are entered in this section. If the difference in the values for the source and applications of funds within a financial year is negative, the model increases the mortgage until the final balance is equal to zero.

4.7.7. Application of funds

Applications of funds other than farm expenditure are entered in this section. If the final value of the source of funds is greater than the application of funds, the model uses the 'surplus' to pay principal on the mortgage.

4.7.8. Mortgage initial balance & interest rate

The mortgage initial balance refers to the balance of the farmer's mortgage in 1996. This value is used to calculate how much interest the farmer needs to pay per year in the application of funds section. When the 'surplus' between the source and application of funds is negative the model increases the principal on the mortgage to fund the overdraft (Section 4.7.6). The interest rate entered in the model is the rate charged on the farmer's mortgage.

4.8. Risk modeling:

4.8.1. Introduction

In this study the probability distribution of net operating profit after tax and before interest (NOPAT) was used as a measure of business risk. Expected NOPAT for the farm system is simulated with the probability distribution of inputs using the @Risk software. This software has been used by other authors for solving similar problems (Purvis et al., 1995; Patrick and DeVuyst, 1995).

4.8.2. Risk model input template

The stochastic values for weather and price, and their respective probabilities are entered in the risk modelling input template. Price risk is entered by fitting the historical data to a Fourier curve (Equation 13 & Equation 14). The variables in the equation, and the number of years per cycle, and the year the model should use as the first year of a cycle is then entered into this template (Figure 10). Production risk is calculated using the historical data on the farm's water balance deficit and the variation in animal production expected by the farmer (Figure 11). The latter are estimated subjectively and used in Equation 15 and Equation 16. Gross cattle revenue for the current year is calculated accounting for the stochasticity in price and production as shown in Equation 17.

$$\beta = \frac{z}{s} \mathrm{x} 360 \mathrm{x} \frac{\pi}{180}$$ **Equation 13**

$$P_j = a + b\cos\beta + c\cos 2\beta + d\sin\beta + e\sin 2\beta$$ **Equation 14**

Where:

β = value in radians for the year;
z= year in the cycle;
s = number of years of the cycle;
P_j = cattle price for the ith month of the jth year (NZ$);
a = intercept in the Y-axis (stochastic);
b, c, d, e = coefficients for the Fourier curve (stochastic).

$$R_j = \frac{(W_j - \overline{W})}{\overline{W}}$$ **Equation 15**

$$V_j = R_j x f + R_{j-1} x g$$ **Equation 16**

Where:

R_j = amount of deficit of the jth year as a rate of an average year;
W_j = water deficit for the jth year;
$\overline{W}$ = water deficit of an average year;
V_j = decrease/increase in production for current year;
f = percentage decrease/increase in production for a bad/good year;
g = percentage decrease/increase in production as a consequence of previous bad/good year.

$$G_j = Cr_j * \frac{P_j}{P_{1996}} * (1 + V_j)$$ **Equation 17**

Where:

G_j = gross cattle revenue in the jth year;
Cr_j = gross cattle revenue in the jth year given 1996 prices;
P_{1996} = cattle price for 1996.

	value	SE
Intercept (a)	580.79	16.92
b	-139.08	24.65
c	-10.09	23.59
d	-21.41	23.09
e	42.08	24.08

Number of years/cycle	7

Year	Prob	CumProb	Risk
7	0.25	0.25	0.5
1	0.5	0.75	
2	0.25	1	

Figure 10: Stochastic data for price risk modelling.

Expected Drought (water deficit-mm)	Cummulative probability
200	0.06
250	0.13
300	0.34
350	0.53
400	0.74
450	0.89
500	0.96

	Good year Exp gain	Bad year Exp loss
Year	0.1	0
Next Year	0.05	0.05

Figure 11: Stochastic data for modelling production risk.

4.9. Summary/conclusion:

In this Chapter the stochastic model built for calculating the profitability and feasibility of pasture development in both Brazil and New Zealand was presented. Data inputs to the model were explained. In the following Chapter the results obtained for the Brazilian and New Zealand case farms are presented.

Chapter Five: Results and Discussion

5.0. Introduction:

In this Chapter the model results for developing the Brazilian and New Zealand case farm are presented. Two rates of development were used for each farm and compared with the continuation of the status quo.

5.1. Results and Discussion for the Brazilian case farm:

Two rates of development, 200 ha/y and 500 ha/y, were tested for the Brazilian case farm for the conversion of 2263 ha of native pastures into improved pastures with greater production and quality. Present (1996) prices and interest rates were used in the initial deterministic analysis of the profitability and feasibility of the two rate options. Stochastic price and weather variables were then incorporated and the data analysed in terms of stochastic dominance of the different scenarios. Two interest rates (16 vs 6%) were then used in the analysis of the results because the economic situation in Brazil is stabilising and a high interest rate is not expected to be sustained in the long term.

5.2. Status quo with minimal further development:

Continuation of the pre-development status quo situation of the farm is influenced to some extent by the 760 ha developed in 1995. This is expected reach full production by 1997 (i.e. k=3) The model predicts a 2.9% increase in the farm's stocking rate as a consequence of this extra pasture production. The beef cattle status quo stock reconciliation (Table 21) shows the number of cattle and sales in each animal class. Farm cash expenditure increases from the status quo of NZ$ 588,600 to NZ$ 589,700 in 1996 due to increased animal health costs because of the greater number of cattle (Table 22).

Table 21: Beef cattle stock reconciliation for the 1997/98 status quo for the Brazilian case farm - the numbers in brackets refer to 1996/97season.

Categories	Predicted stock numbers (1996)	Predicted natural increase (1996)	Predicted net sales (1996)
Calves		1389 (1349)	
R1Hfrs	667 (648)		234 (227)
R2Hfrs	426 (414)		134 (130)
R3Hfrs	271 (236)		0
Cows	1029 (1000)		206 (200)
R1Steers	333 (324)		0
R2Steers	330 (321)		313 (305)
R1Bulls	333 (324)		316 (306)
R2 Bulls	14 (14)		0
B'dg Bulls	51 (50)		10 (10)
Total	3454 (3358)		

5.2.1. Profitability and feasibility of the status quo at 1996 prices

The profitability of the farm's status quo situation given 1996 beef cattle prices is good. The farm would, by 1997, have a gross revenue of NZ$ 800,489 and by 1999 when tax payments stabilise, have a NOPAT before interest of NZ$ 105,707 (Table 22). With respect to feasibility, the farm would be debt free by the year 2002 when the farm's mortgage of NZ$ 118,000, at an interest rate of 16% pa, would be repaid in full (Table 23). Continuation of the status quo with the 1995 development included has a NPV of NZ$ 42,935 at a 16% post-tax discount rate.

Table 22: Profitability analysis for the status quo (SQ) at 1996 prices for the Brazilian case-farm.

Year	SQ	1996	1997	1998	1999
Gross Revenue					
Beef cattle	450,371	428,083	462,989	463,343	463,426
Other farm income	337,342	=[1]	=	=	=
Change in stock	0	15,219	158	11	-38
Gross farm revenue	787,713	780,644	800,489	800,696	800,730
Farm expenses					
Farm cash expenditure	588,663	589,718	589,729	589730	589,727
Depreciation	70,000	=	=	=	=
Farm Profit b4 tax	129,050	120,926	140,760	140,967	141,003
Provisional tax	33,876	33,876	31,743	36,950	37,004
Terminal tax	-1,613	-1,613	-3,644	3,447	-1,708
NOPAT b4 interest	**96,787**	**88,644**	**112,661**	**100,570**	**105,707**

[1] The character (=) means 'same as previous value'.

Table 23: Feasibility analysis for the status quo (SQ) at 1996 prices for the Brazilian case farm.

Year	SQ	1996	1997	1998	1999	2000	2001	2002
Source of funds								
Farm profit b4 tax	129,050	120,926	140,967	141,925	141,003	140,925	141,009	140,951
(+) depreciation	70,000	=	=	=	=	=	=	=
(-) change in stock	0	15,219	158	11	-38	49	-34	22
Farm cash surplus	199,050	175,707	210,602	210,956	211,041	210,876	211,043	210,929
Borrowing	0	14,909	0	0	0	0	0	0
Total	**199,050**	**190,616**	**210,602**	**210,956**	**211,041**	**210,876**	**211,043**	**210,929**
Application of funds								
Plant and vehicles	70,000	=	=	=	=	=	=	=
Drawings	73,500	=	=	=	=	=	=	=
Tax	32,262	32,262	28,099	40,396	35,296	35,260	35,211	35,275
Interest. Net of Tax	14,160	14,854	14,854	11,956	10,144	7,491	4,537	1,201
Principal payment	9,127	0	24,149	15,103	22,101	24,624	27,796	10,009
Total	**199,050**	**190,616**	**210,602**	**210,956**	**211,041**	**210,876**	**211,043**	**189,984**
Difference in funds	0	0	0	0	0	0	0	20,945
Mortgage	**118,000**							
Final balance	**108,873**	**123,782**	**99,633**	**84,530**	**62,429**	**37,805**	**10,009**	**0**

5.3. Development program:

5.3.1. Investment costs

The per hectare development cost for the Brazilian case farm is NZ$ 412 (Table 24). If all of the native pasture area (2263 ha) was to be developed in the first year, the cost would be NZ$

932,424. When the pasture is developed over time at either 200 or 500 ha/y and the investment is discounted at either 6 or 16% a present value of between NZ$ 418,763 and NZ$ 794,840 is predicted, as shown in Table 25.

Table 24: Pasture development cost (1996 NZ$) for the Brazilian case farm.

Item	Cost (NZ$)	Cost/ha
Fertiliser	160/ton	140.00
Annual ryegrass seeds	0.71/kg	21.30
Avena sp. seeds	0.50/kg	20.00
White clover seeds	7.86/kg	23.58
Lotus sp seeds	6.43/kg	22.50
Freight	21.43/ha	21.43
Plough	22.86/h	102.87
Sowing	22.86/h	45.72
Labour	2.25/h	14.63
Total/ha		**412.03**

Table 25: Net Present Value of the investment costs for different development and discount rates for the Brazilian case farm.

Rate of development	Discount rate	
	6%	16%
200 ha/y	662,826	418,763
500 ha/y	794,840	628,061

5.3.2. Increase in farm's cash expenditure for the development program

If the development program is pursued, annual farm cash expenditure by the end of the project (200 or 500 ha pa), is predicted to increase from NZ$ 588,600 to NZ$ 631,000 due to more outlay on input items such as fertiliser, animal health, seeds, and weed and pest control. These expenses are directly correlated with the increased area of improved pasture and greater number of cattle. Fertiliser was entirely associated with the increased area of improved pasture since the only pastures receiving fertiliser are those in this category. Eighty percent of the increase in animal health costs are associated with the increase in stocking rate. This reflects the possibility of getting a better bulk (20% saving) for animal health products. Half of the seed costs are associated with the oversowing needed to maintain improved pastures and thus this increases in conjunction with greater pasture improvement. Weed and pest costs increase by 50% due to the more intensive control of these problems on the improved pasture area. Labour was not considered to be correlated with increased stock numbers due to surplus labour on the farm at present.

5.3.3. Increase in stocking rate

The extra pasture produced by the improved pasture is used in the model to increase the stocking rate of the farm. The model predicts an 54% increase in the stocking rate of the farm due to the development of 2,263 ha. The beef cattle stock reconciliation (Table 26) shows the cattle numbers and sales at the end of the development project .

Table 26: Beef-cattle stock reconciliation for the end of the development program for the Brazilian case farm and for 1996 (shown in brackets - see Table 21).

Categories	Predicted stock numbers (1996)	Predicted natural increase (1996)	Predicted net sales (1996)
Calves		2078 (1349)	
R1Hfrs	997 (648)		350 (227)
R2Hfrs	637 (414)		200 (130)
R3Hfrs	405 (263)		0
Cows	1540 (1000)		308 (200)
R1Steers	499 (324)		0
R2Steers	494 (321)		469 (305)
R1Bulls	499 (324)		472 (306)
R2 Bulls	22 (14)		0
B'dg Bulls	77 (50)		16 (10)
Total	5170 (3358)		

5.3.4. Profitability and feasibility of developing 200 ha/y at 1996 prices and 16% interest rate

The development of 200 ha/y at 1996 prices is not profitable at a 16% discount rate, the current real interest rate in Brazil (Table 27). The project's post-tax NPV of NZ$ 41,164 becomes a loss of around NZ$ 1,700 when compared with the NZ$ 42,935 post-tax NPV for the status quo. Thus, if the project is implemented, it will never payback the costs of development (Figure 12).

Table 27: NPV for the different scenarios at 1996 prices (NZ$) and a 16% discount rate for the Brazilian case farm.

Scenario	NPV for first 20 years	Salvage value	Total NPV
Status quo	40,117	2,818	42,935
Dev. 200 ha/y	(6,406)	47,570	41,164
Dev. 500 ha/y	(33,109)	47,570	14,461

The feasibility analysis of developing 200 ha/y at a 16% discount rate and 1996 prices (Figure 13), shows that the farm will have a mortgage of NZ$ 1,100,000 by 2006 when debt will start to be repaid. This mortgage would the farm development program almost infeasible because the interest payment of NZ$ 132,000 in 2007 is around 92% of the farm's surplus in that year. However, by 2015 interest payment are down to 52% of the farm's surplus. If the economic situation in Brazil does not improve and the interest rate remains at its present level or increases, lending institutions may be unwilling to loan funds or would add a premium to the 16% interest rate to account for greater risk. Under these circumstances the project would be infeasible.

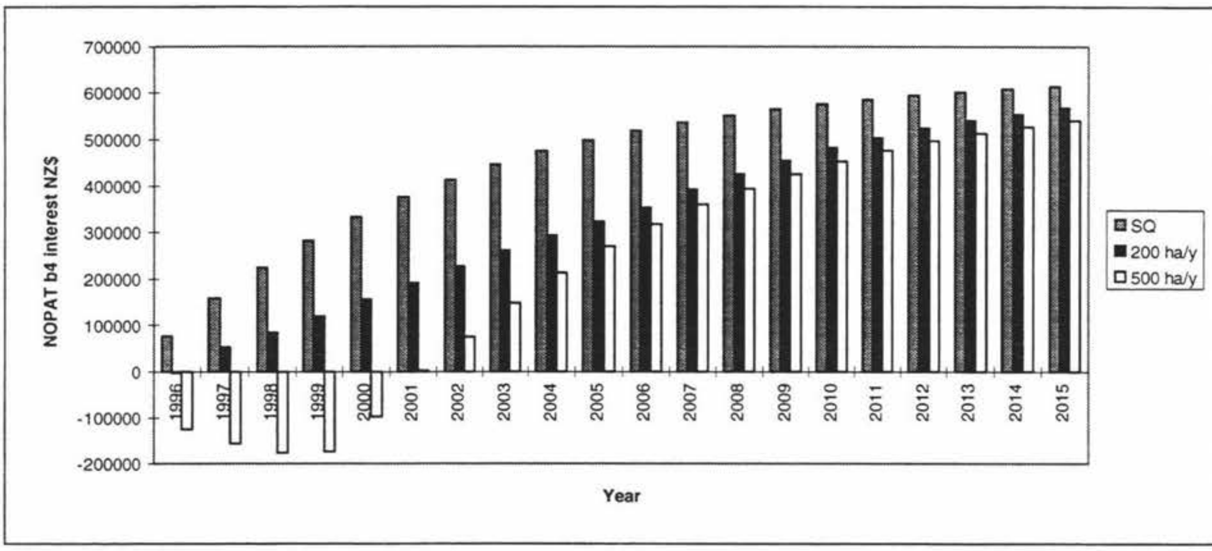

Figure 12: Cumulative discounted NOPAT b4 interest for status quo and for developing 200 and 500 ha/y for the Brazilian case farm.

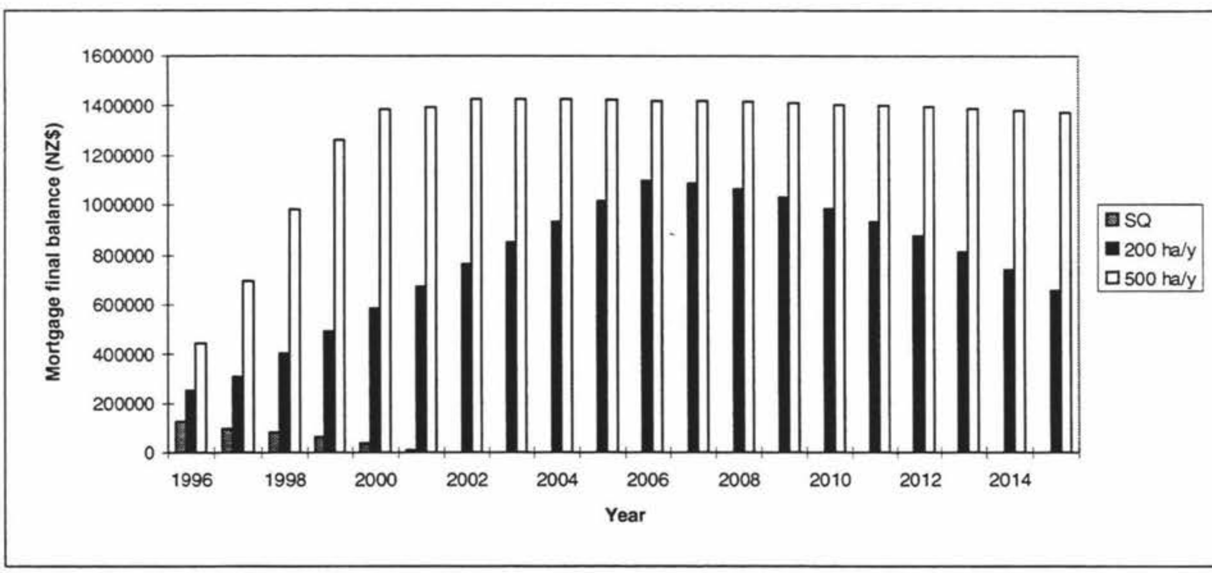

Figure 13: Mortgage final balance for status quo and for developing 200 and 500 ha/y for the Brazilian case farm.

5.3.5. Profitability and feasibility of developing 500 ha/y at 1996 prices and 16% interest rate

The development of the 2263 ha of native pastures at 500 ha/y was profitable at a 16% discount rate and 1996 beef cattle prices (Table 27). The project's post-tax NPV of NZ$ 14,461 becomes a loss of NZ$ 28,474 when compared with the status quo post-tax NPV of NZ$ 42,935. Thus, if a 500 ha/y development program is implemented, it would never achieve payback and the loss would be greater than for developing 200 ha/y (Figure 12).

The feasibility analysis of developing 500 ha/y (Figure 13) shows the farm has a mortgage of NZ$ 1,428,000 by the year 2002, when debt starts to be slowly repaid. The interest payment in 2003 is 99.9% of the farm's surplus and, by 2015, the interest payment is still very high at 95.5% of the farm's surplus. The long time period for the farm to repay its debt would render the 500 ha/y option infeasible. The main problem for this scenario is that funds, in addition to those required for development, need to be borrowed during the first five years to meet interest payments. In contrast, the 200 ha/y option is able to be partially funded from surpluses generated by the farm and the mortgage is not as large, allowing the farm to repay the debt faster, once the project is finished, than the 500 ha option (Figure 13).

5.4. Business risk:

The incorporation of price and production risk into the analysis changed the value of the NOPAT before interest for the development program. The Brazilian beef cattle prices in 1996 where assumed to be at a high on a six year cycle (Figure 14). The historical pattern of beef cattle prices is reasonably consistent because most Brazilian beef produced is sold on the internal market.

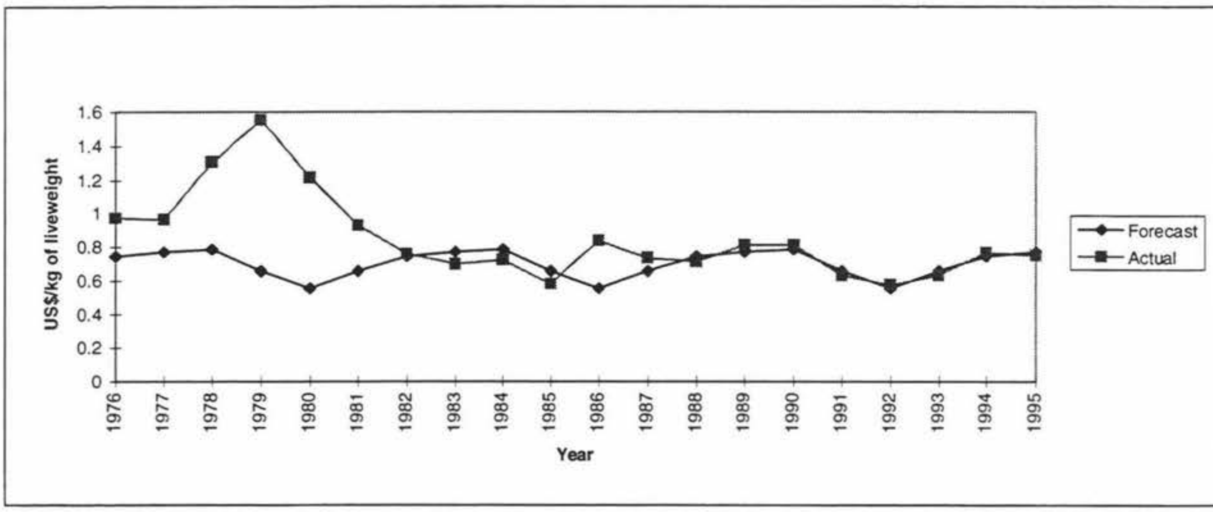

Figure 14: Historical and forecasted beef cattle prices for Brazil (see Appendix I for the actual data series, and Section 4.8 for a description of the prediction equation).

Production risk was incorporated by simulating the variation in rainfall between years because drought is the most important weather constraint the farm faces. The probabilities of annual rainfall were based on the cumulative probability distribution of the water balance deficit for the local historical data (Figure 15). The effect of rainfall variation on cattle performance (i.e. liveweight at sale) was based on the farmer's experience (Martins, 1996 pers. comm.). The average water balance deficit is 199 mm pa. When the water balance deficit is as low as 50 mm the farmer expects cattle to gain 5% in liveweight for the present year and a further 5% the following year. On the other hand, when the water balance deficit is as high as 400 mm, the farmer expects cattle liveweights at sale to be 15% lower and a carry-over reduction of 5% to occur in the next year. Production and price risk was incorporated using these data for the three scenarios analysed: status quo, development of 200, and 500 ha/y.

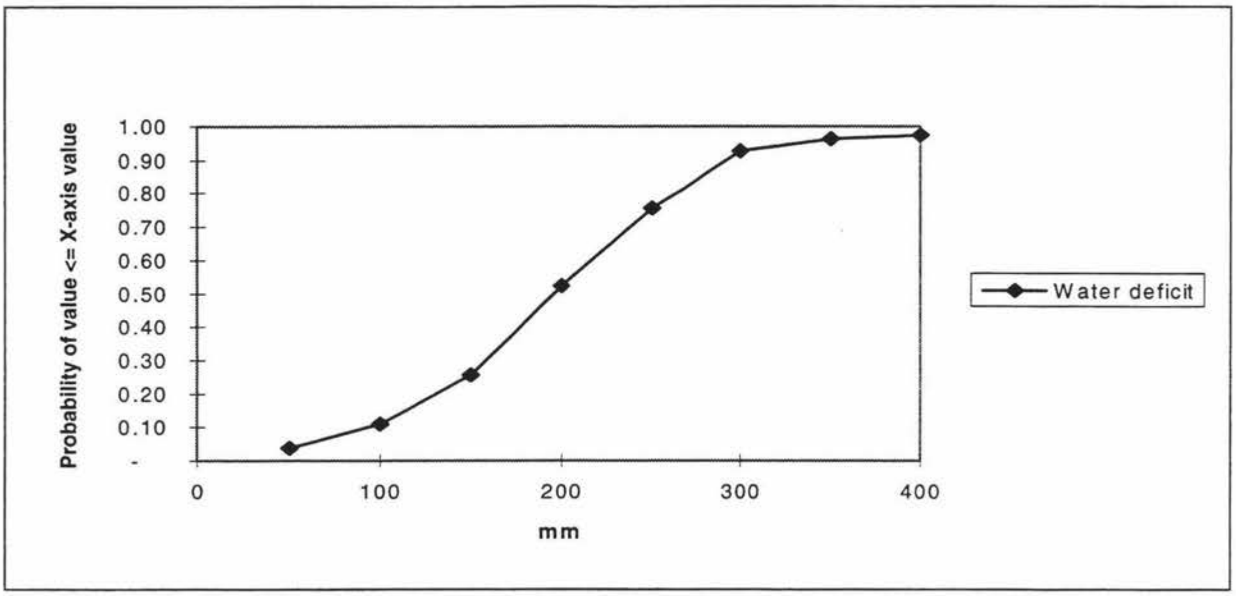

Figure 15: Cumulative distribution of water balance deficit for the Brazilian case farm (see Appendix II for rainfall and evapotranspiration data).

5.4.1. NOPAT before interest

The cash flows for the Brazilian case farm (Figure 16) shows variation in the NOPAT before interest for the status quo due to both the production increase in 1997 and the trend in beef cattle prices. The error bars represent the uncertainty, standard deviation (sd.) of the mean NOPAT for the year, in relation to the possible prices and weather conditions for the farm in the status quo situation. The farm's NOPAT for the status quo is predicted to be around NZ$ 65,000 and not the NZ$ 100,000 predicted using cattle prices fixed at those realised in 1996 (Table 22).

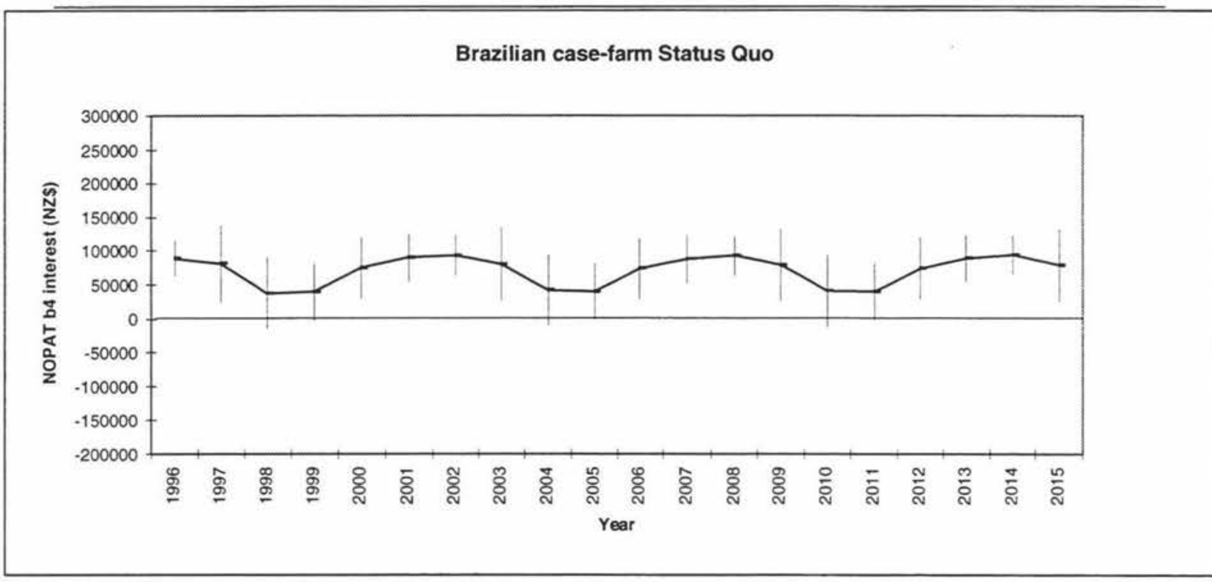

Figure 16: NOPAT before interest (mean ± sd.) for the Brazilian case farm assuming the present (1996) state of pasture development.

For the case where 200 ha/y is developed (Figure 17), the model predicts the farm would have a NOPAT of around zero until close to the year 2001, when cattle prices increase and the NOPAT improves to around NZ$ 70,000. The model predicts the NOPAT to stabilise at around NZ$ 190,000 by the year 2007 when the remaining 63 ha would be developed and the beef schedule would be increasing again.

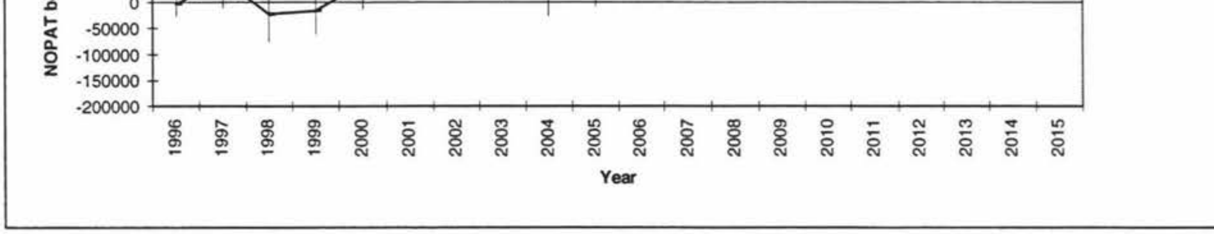

Figure 17: NOPAT before interest (mean ± st. dev.) for the Brazilian case farm developed at 200 ha/y.

When developing 500 ha/y (Figure 18) the model predicts the farm would have a negative NOPAT until the year 2000. In fact in the first four years, the farm would have an annual overdraft of around NZ$ 100,000. By 2000, all 2263 ha would be developed and the farm's NOPAT would stabilise at about NZ$ 190,000 pa. and reflect the trend in cattle prices shown in Figure 14.

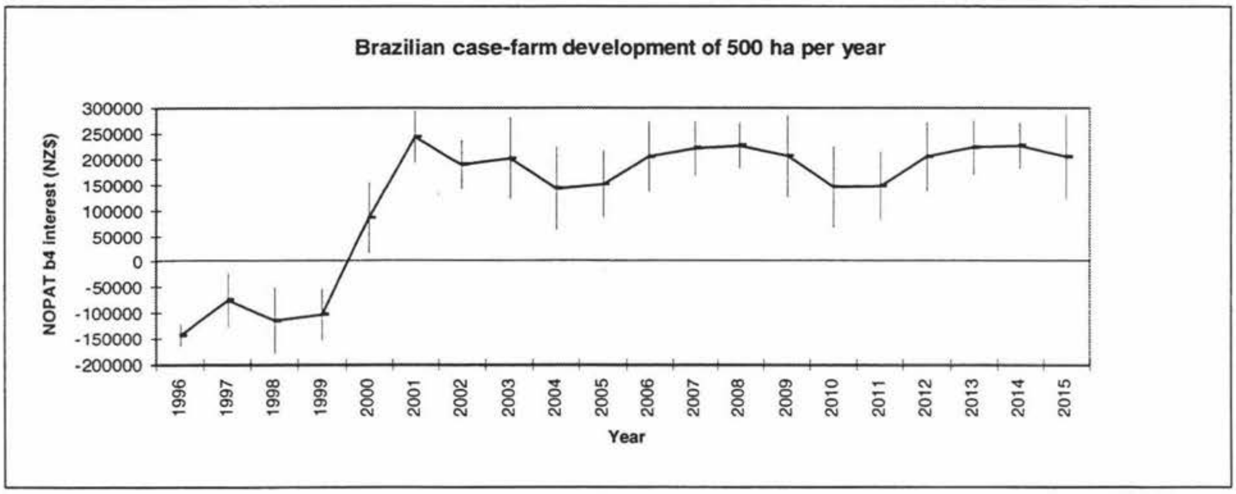

Figure 18: NOPAT before interest (mean ± st. dev.) for the Brazilian case farm developed at 500 ha/y.

5.4.2. Discussion of the outcomes at a 16% interest rate

The results for the Brazilian case farm show that developing native pasture into improved pasture is not profitable at a 16% discount rate when production and price risk are incorporated in the model. Losses are greater for developing 500 ha/y than 200 ha/y (Figure 19 & Table 28). The status quo situation has first degree stochastic dominance over the two rates of development given a 16% discount rate. The farm in the status quo situation increases animal production due to the 760 ha developed in 1995, but the expected decrease in cattle prices, due to 1995/96 being a year of high prices relative to the typical six year cycle, is likely to negate the production increase so that the probability distribution of the NPV for the status quo is close to zero (Figure 19 & Table 28). The salvage value of the project and for the status quo (Figure 20), already incorporated in the NPV (Figure 19), do not have a big influence on the NPV at this very high discount rate. For the development of 200 ha/y or 500 ha/y the salvage value varies from NZ$ 40,000 to NZ$ 45,000, and for the status quo between NZ$ 2,400 and NZ$ 2,700 (Figure 20).

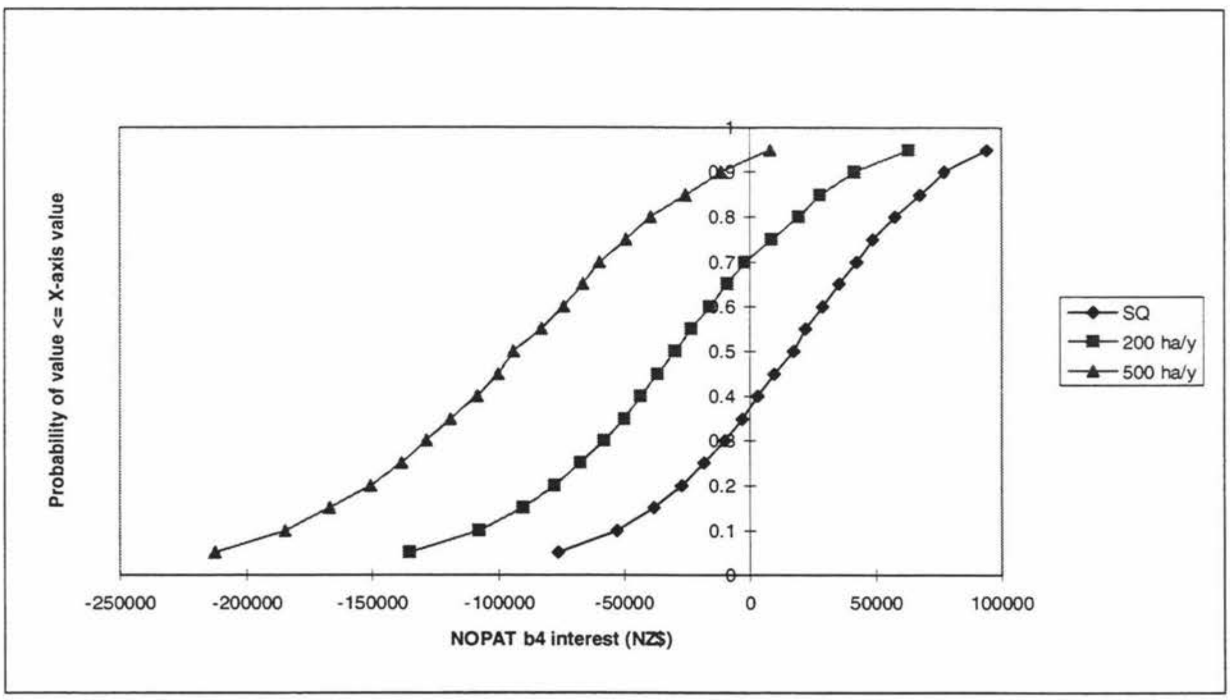

Figure 19: Probability of NPVs for the Brazilian case farm at a 16% discount rate.

Table 28: Probability of NPVs for the Brazilian case farm at a 16% discount rate.

Probability	Status quo	200 ha/y	500 ha/y
5%	-76222	-135178	-212650
10%	-52819	-108107	-184673
15%	-38183	-90510	-166690
20%	-27107	-77905	-150625
25%	-18278	-67458	-138430
30%	-9818	-57871	-128619
35%	-2766	-50057	-119334
40%	3217	-43358	-108921
45%	9622	-36524	-100324
50%	17459	-29803	-94289
55%	22122	-22998	-83126
60%	29015	-15768	-74024
65%	35368	-8581	-66297
70%	42150	-1802	-59863
75%	48929	8692	-49018
80%	57394	19323	-39423
85%	67472	27880	-25415
90%	77175	41400	-11267
95%	94279	63216	8015

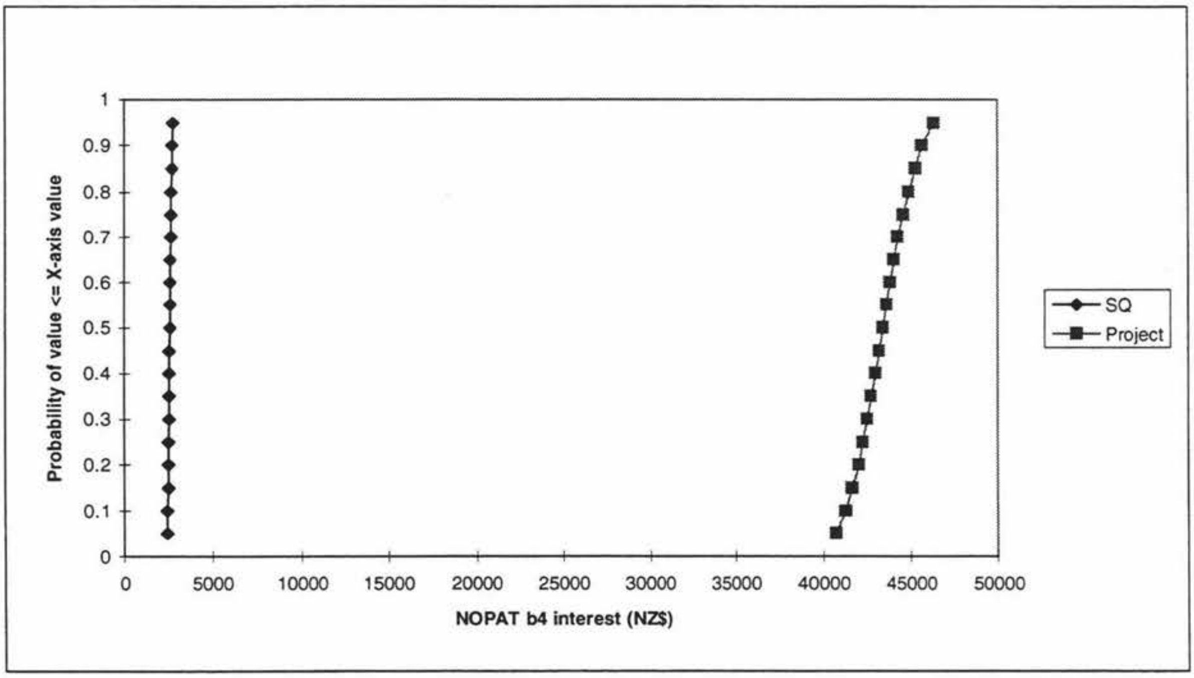

Figure 20: Probability of NPVs of the salvage value for the Brazilian case farm at a 16% discount rate.

5.4.3. Discussion of the outcomes at a 6% interest rate

A discount rate of 6% was also used to evaluate the development option because interest rates are likely to fall in the short term as the Brazilian economy recovers. The current very high interest rates are part of a monetary policy to prevent capital being used for consumption before production increases. In simple terms this is based on the notion that if money is used for the consumption of goods at this stage, national production would be unable to meet demand, and as a consequence prices would rise and there would be upward pressure on inflation.

In February 1996, 40 financial consultants and bankers were surveyed and they predicted of interest rates would decline from 16% in 1996 to 8% in 1997/98 and 6% by the year 2000 (Veja, 1996). At a 6% discount rate, the development project is profitable and the salvage value of the project significantly increases (Figure 22). The NPV is positive for all of the probability distribution curve for both 200 ha/y and 500 ha/y rates of development (Figure 21 & Table 29). In contrast to the 16% discount rate scenario, the 500 ha/y project has first degree stochastic dominance over both the 200 ha/y and status quo options.

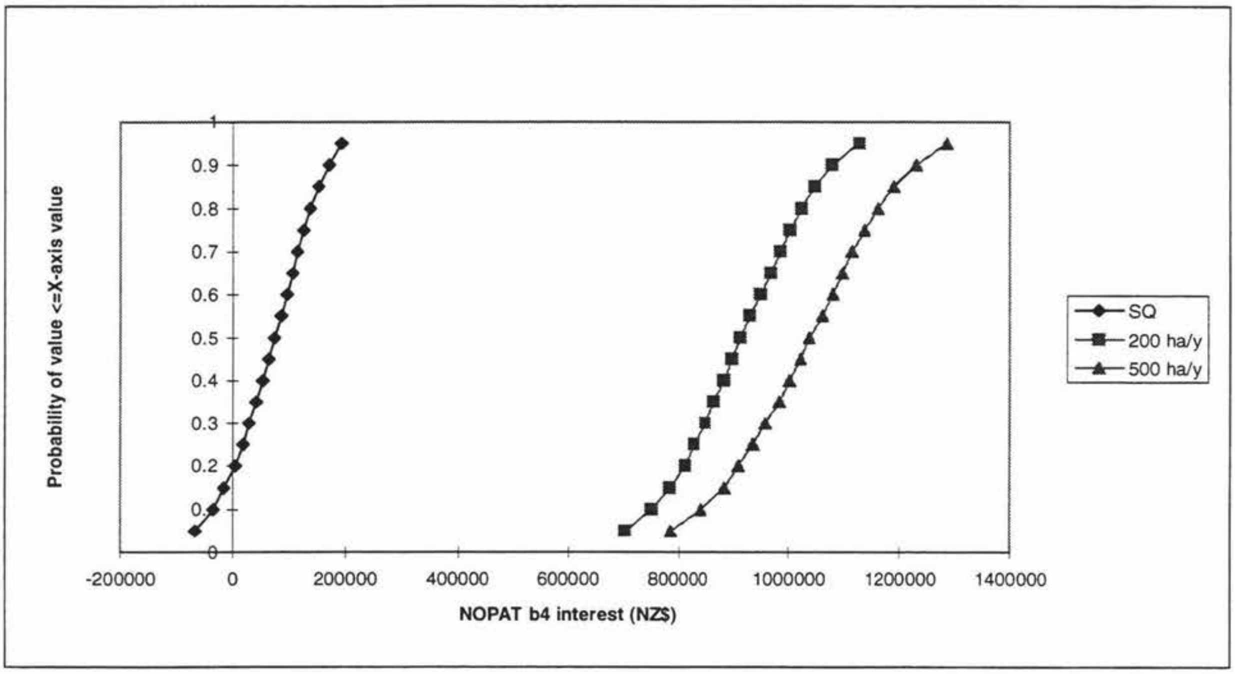

Figure 21: Probability of NPVs for the Brazilian case farm at a 6% discount rate.

Table 29: Probability of NPVs for the Brazilian case farm at a 6% discount rate.

Probability	Status quo	200 ha/y	500 ha/y
5%	-66650	703515	785287
10%	-34891	750451	843642
15%	-16029	782816	884655
20%	5305	812228	911265
25%	18288	829374	937059
30%	28514	851603	958725
35%	40550	866337	984548
40%	51456	885290	1001236
45%	62122	899560	1021392
50%	72594	914773	1036577
55%	84089	931130	1061076
60%	95284	950410	1079050
65%	104568	968932	1097052
70%	114269	985623	1113890
75%	125847	1003369	1135484
80%	137445	1023927	1162280
85%	152260	1048087	1190359
90%	170609	1078505	1231869
95%	194012	1127194	1286445

The NPV of the status quo improves in relation to the 16% discount rate analysis due to the increased production from the 760 ha developed in 1995 being discounted at a lower rate. The salvage value for the status quo at a 6% discount rate is between NZ$ 39,000 and NZ$ 44,000. The salvage value of the project improves and is, at a 6% discount rate, between NZ$ 658,000 and NZ$ 750,000 (Figure 22).

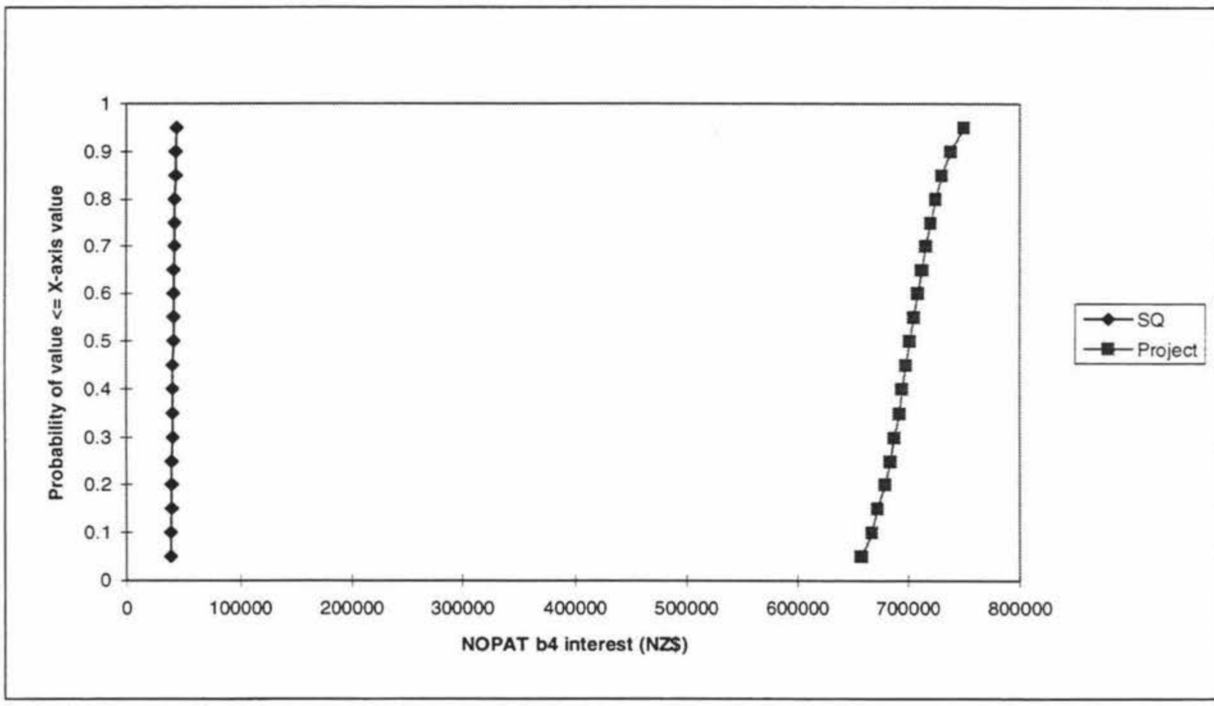

Figure 22: Probability of NPVs of the salvage value for the Brazilian case farm at a 6% discount rate.

5.5. New Zealand case farm results and discussion:

Two rates of development, 25 ha/y and 50 ha/y, were tested for the New Zealand case farm for the development of 247.4 ha of 'native' pastures into improved pastures. Present (1996) prices and real interest rates were used in the initial deterministic analysis of profitability and feasibility for the two rates of development. Stochastic price and weather variables were then incorporated and the data analysed in terms of stochastic dominance for the different scenarios.

5.6. Status quo with minimal further development:

Continuation of the pre-development status quo situation of the farm is influenced to some extent by the 41.4 ha developed in 1995 and 7.3 ha developed in 1996. These areas are expected to be in full production in 1997 and 1998, respectively. The model predicts a 2.9% increase in the farm's stocking rate as a consequence of this extra pasture production. The beef cattle status quo stock reconciliation (Table 30) shows the number of cattle and sales in each animal class. The small increase in farm cash expenditure from the status quo to 1997 is due to increased animal health costs because of the greater number of cattle (Table 31).

Table 30: Beef cattle stock reconciliation for the 1998/99 status quo - the numbers in brackets refer to 1996/97 for the New Zealand case farm.

Categories	Predicted stock numbers (1996)	Predicted natural increase (1996)	Predicted net sales (1996)
Calves		600 (598)	
R1Hfrs	297 (296)		207 (206)
R2Hfrs	75 (75)		70 (70)
R3Hfrs	0		-133 (-133)
Cows	667 (665)		106 (106)
R1Steers	297 (296)		-208 (-207)
R2Steers	501 (500)		299 (298)
R3Steers	193 (192)		189 (188)
B'dg Bulls	19 (19)		-1 (-1)
Total	2049 (2043)		529 (527)

Table 31: Profitability analysis for the status quo at 1996 prices for the New Zealand case farm.

Year	Status quo	1996	1997	1998	1999
Gross Revenue					
Beef cattle	301,385	300,582	301,946	302,070	302,070
Other farm income	593,102	= [1]	=	=	=
Change in stock	0	709	58	0	0
Gross farm revenue	894,467	894,373	895,106	895,172	895,172
Farm expenses					
Farm cash expenditure	817,479	817,566	817,573	=	=
Depreciation	40,405	=	=	=	=
Farm Profit b4 tax	36,583	36,402	37,128	37,194	=
Provisional tax	9,603	9,603	9,556	9,746	9,763
Terminal tax	-457	-457	-502	-273	-448
NOPAT b4 interest	**27,437**	**27,256**	**28,075**	**27,721**	**27,879**

[1] The character (=) means 'same as previous value'.

5.6.1. Profitability and feasibility of the status quo at 1996 prices

The profitability of the farm's status quo situation given 1996 beef cattle prices is reasonable. The farm would, by 1997, have a gross revenue of NZ$ 895,106 and, by 1999 when tax payments stabilise, have a NOPAT before interest of NZ$ 27,879 (Table 31).

Table 32: Feasibility analysis for the status quo at 1996 prices for the New Zealand case farm.

Year	SQ	1996	2000	2005	2010	2015
Source of funds						
Farm profit b4 tax	36,583	36,402	37,194	37,186	37,200	37,109
(+) depreciation	40,405	=	=	=	=	=
(-) change in stock	0	709	0	0	0	0
Farm cash surplus	76,988	76,098	77,599	77,579	77,612	77,514
Shell rock	6,000	=	=	=	=	=
Non-farm income	45,000	=	=	=	=	=
Borrowing	42,213	45,133	52,643	66,292	83,408	105,118
Total	**170,200**	172,231	181,242	194,871	212,019	233,632
Application of funds						
Plant and vehicles	40,405	=	=	=	=	=
Drawings	40,000	=	=	=	=	=
Tax	9,146	9,146	9,299	9,299	9,293	9,303
Interest. payment[1]	80,650	91,538	94,591	105,167	122,322	143,923
Principal payment	0	0	0	0	0	0
Total	**180,247**	**182,752**	**193,890**	**210,793**	**232,064**	**258,865**
Mortgage						
Final balance	**1,792,213**	**1,837,345**	**2,034,184**	**2,337,042**	**2,718,263**	**3,198,293**

[1] Net of Tax

With respect to feasibility, however, the scenario is not healthy given 1996 beef prices. The farm would not be able to pay the interest on its debt and would need to keep on borrowing capital to pay the annual interest. Under this scenario, debt is predicted to increase from NZ$ 1,750,000 to NZ$ 3,198,293 by the year 2015 (Table 32). Continuation of the status quo with 1995 and 1996 development included has a NPV of NZ$ 6,500 at a 6% post-tax discount rate.

5.7. Development program:

5.7.1. Investment costs

The per hectare development cost for the New Zealand case farm is NZ$ 837 (Table 24). If all of the native pasture area (247.4 ha) was to be developed in the first year the cost would be NZ$ 207,143. When the pasture is developed over time at either 25 or 50 ha pa and the investment is discounted at 6%, a present value of NZ$ 152,846 and NZ$ 174,720 is predicted for the two development rates, respectively.

Table 33: Pasture development cost (1996 NZ$) for the New Zealand case farm.

Item	Cost/ha
Fertiliser	294.37
Fertiliser application	10.85
Seeds	242.30
Freight	44.45
Cultivation	189.37
Weed control	55.95
Total/ha	**837.28**

5.7.2. Increase in farm's cash expenditure for the development program

If the development program is pursued, annual farm cash expenditure is predicted to increase from NZ$ 817,500 to NZ$ 845,000, due to items such as fertiliser, animal health, seeds, and weed and pest control. These expenses are directly correlated with the increased area of improved pasture and greater number of stock. Seventy five percent of the increase in fertiliser costs are associated with the increased area of improved pasture since improved pastures receive a higher maintenance rates of fertiliser. Eighty percent of the increase in animal health costs are associated with the increase in stocking rate. This, in the same way as for the Brazilian case farm, reflects the possibility of getting a better bulk deal price for animal health products. Weed and pest costs increase by 50% due to the more intensive control of these problems on the improved pasture area.

5.7.3. Increase in stocking rate

The extra pasture produced by the improved pasture is to increase the stocking rate of the farm. The model predicts a 19% increase on the stocking rate due to the development of 274.4 ha. The beef cattle reconciliation (Table 34) shows the cattle numbers and sales at the end of the development project .

Table 34: Beef-cattle status quo stock reconciliation for the end of the development program and for 1996 (shown in brackets - see Table 30) for the New Zealand case farm.

Categories	Predicted stock numbers (1996)	Predicted natural increase (1996)	Predicted net sales (1996)
Calves		712 (598)	
R1Hfrs	353 (296)		246 (206)
R2Hfrs	89 (75)		83 (70)
R3Hfrs	0		-158 (-133)
Cows	792 (665)		126 (106)
R1Steers	352 (296)		-248 (-207)
R2Steers	596 (500)		355 (298)
R3Steers	229 (192)		224 (188)
B'dg Bulls	23 (19)		-1 (-1)
Total	2434 (2043)		627 (527)

5.7.4. Profitability and feasibility of developing 25 ha/y at 1996 prices and 6% interest rate

The development of 25 ha/y at 1996 prices is profitable when using a 6% discount rate, the current real interest rate in New Zealand (Table 35). The project's post-tax NPV is NZ$ 128,500: NZ$ 12,000 from the first 20 years of the project and NZ$ 116,500 salvage value given 1996 cattle prices. The payback period (PP) for the development of 25 ha/y is 19 years at 6% discount rate (Figure 23). The PP can be seen in Figure 23 as the number of years the accumulated discounted project's NOPAT takes to equal that of the status quo.

Table 35: NPVs for the three different scenarios at 6% discount rate and 1996 beef cattle prices for the New Zealand case farm.

Scenario	NPV for first 20 years	Salvage value	Total NPV
Status quo	4,600	1,900	6,500
Dev. 25 ha/y	12,000	116,500	128,500
Dev. 50 ha/y	23,300	116,500	139,800

The feasibility analysis of developing 25 ha/y at a 6% discount rate and 1996 prices (Figure 24), shows that there is little difference between the status quo or 25 ha/y scenario because in both cases the farm is unable to pay the interest on its present debt. By the year 2015 the model predicts the farm would have a mortgage of NZ$ 3,264,000. The project is profitable at 1996 prices but the result is not sufficient to overcome the build-up of farm debt. If 1996 cattle prices persist and other farm activities maintain current average results more changes in the farm business would be needed before development could proceed.

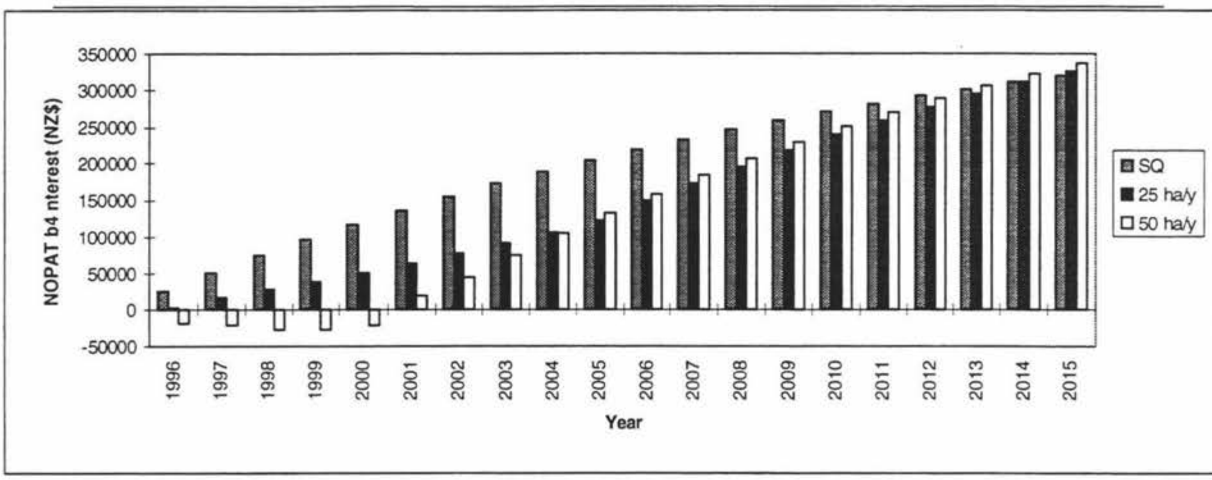

Figure 23: Cumulative discounted NOPAT b4 interest for status quo and for developing 25 and 50 ha/y for the New Zealand case farm.

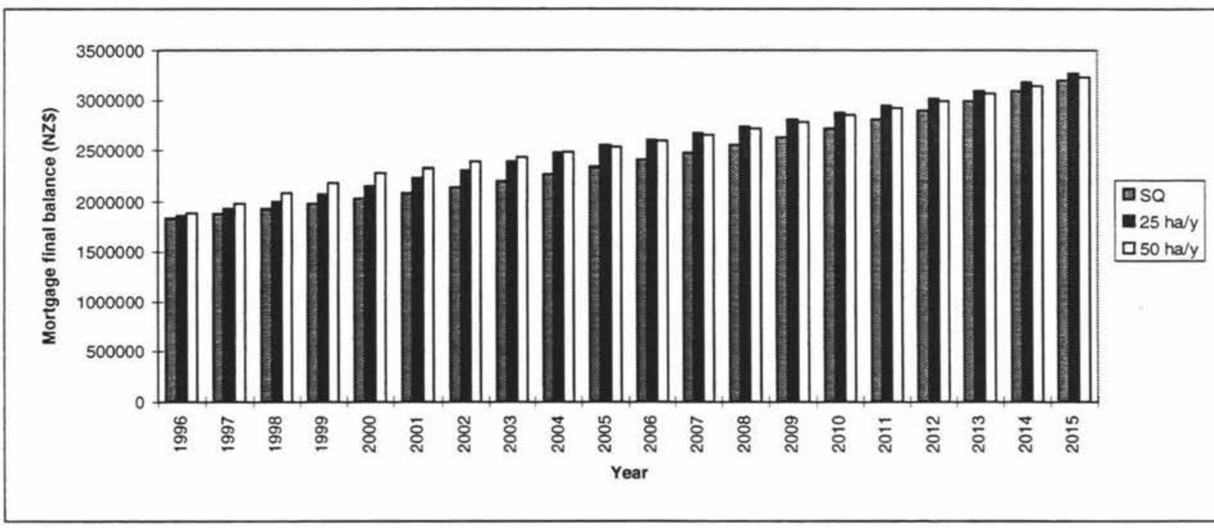

Figure 24: Mortgage final balance for Status quo and for developing 25 and 50 ha/y

5.7.5. Profitability and feasibility of developing 50 ha/y at 1996 prices and 6% interest rate

The development of the 247.4 ha of 'native' pastures at a 50 ha/y rate was shown to be profitable at a 6% discount rate and 1996 beef cattle prices (Table 35). The project's NPV of

NZ$ 139,800 represents an advantage of NZ$ 133,300 when the NZ$ 6,500 status quo NPV is deducted. If a 50 ha/y development program is implemented, it would payback in 18 years at a 6% discount rate (Figure 23).

The feasibility analysis of developing 50 ha/y (Figure 24) shows a scenario similar to that of developing 25 ha/y. The mortgage of the farm would continue to increase due to the fact that the farm business is unable to generate enough funds to meet interest payments.

5.8. Business risk:

The incorporation of price and production risk into the analysis changed the value of the NOPAT before interest for the development program. The New Zealand beef cattle prices assumed to be at a low on a seven year cycle (Figure 25). The historical pattern of prices is not very consistent because beef cattle prices in the international market are influenced by many factors that are not easily predicted. Nevertheless, beef cattle prices for New Zealand are expected to increase in association with the current (1997) decrease in beef cattle numbers in the United States of America.

Production risk was incorporated by simulating between year the variation in rainfall; summer drought is the most important weather constraint of the farm. Historical data were used to derive the cumulative probability distribution of a water balance deficit (Figure 26). The effect of rainfall variation on cattle performance (i.e. liveweight at sale) was assessed by the farmer (Pearce, 1996 pers. comm). The average water balance deficit is 342 mm pa. When the water balance deficit is as low as 200 mm the farmer expects cattle to gain 10% in liveweight for the present year and a further 5% the following year. On the other hand, when the water balance deficit is as high as 500 mm the farmer does not expect cattle liveweights at sale to be lower but a carry-over reduction of 5% in sale weights is expected in the following year. Production and price risk were incorporated for the three scenarios analysed: status quo, and the development of 25 and 50 ha/y.

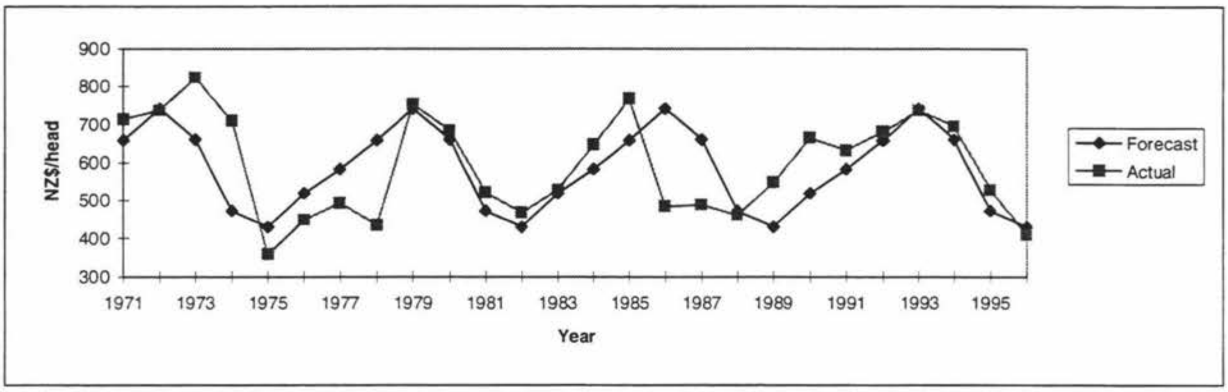

Figure 25: Historical and forecasted beef cattle prices for New Zealand.

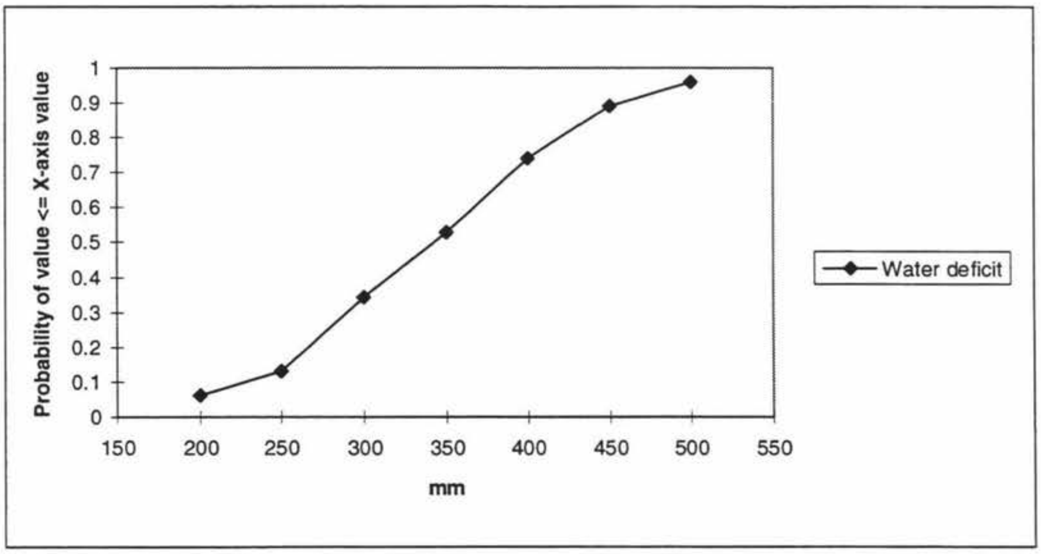

Figure 26: Cumulative distribution of the water balance deficit for the New Zealand case farm.

5.8.1. NOPAT before interest

The cash flows for the New Zealand case farm (Figure 27) shows variation in the NOPAT before interest for the status quo due to both the production increase in 1997 and the trend in beef cattle prices. The error bars represent the uncertainty (standard deviation (sd.) of the mean NOPAT) in relation to the possible prices and weather conditions for the farm in the status quo situation. The farm's NOPAT for the status quo is predicted to be around NZ$ 65,000 and not the NZ$ 27,000 estimated when cattle prices were fixed at those realised in 1996 (Table 31).

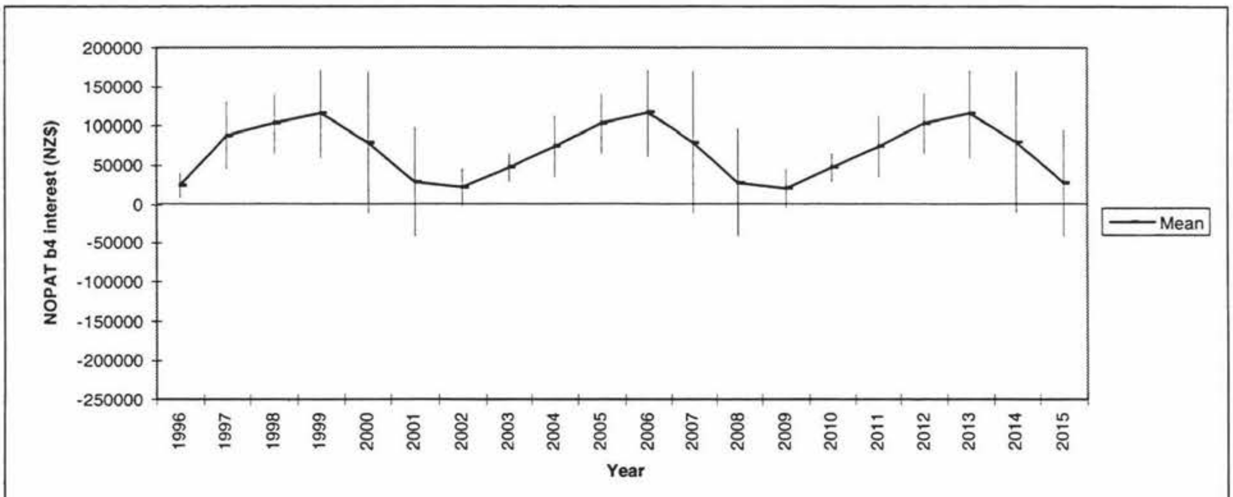

Figure 27: NOPAT before interest for the New Zealand case farm assuming the present (1996) state of pasture development.

For the case where 25 ha/y is developed (Figure 28) the NOPAT of the farm is around NZ$ 60,000 until 2001, when it increases to an average of NZ$ 80,000 between 2002 and 2008 before, finally, stabilising at NZ$ 95,000 when the project finishes. The influence of predicted price and production variability on the farm's NOPAT appears to overcome the influence of the project itself at this development rate.

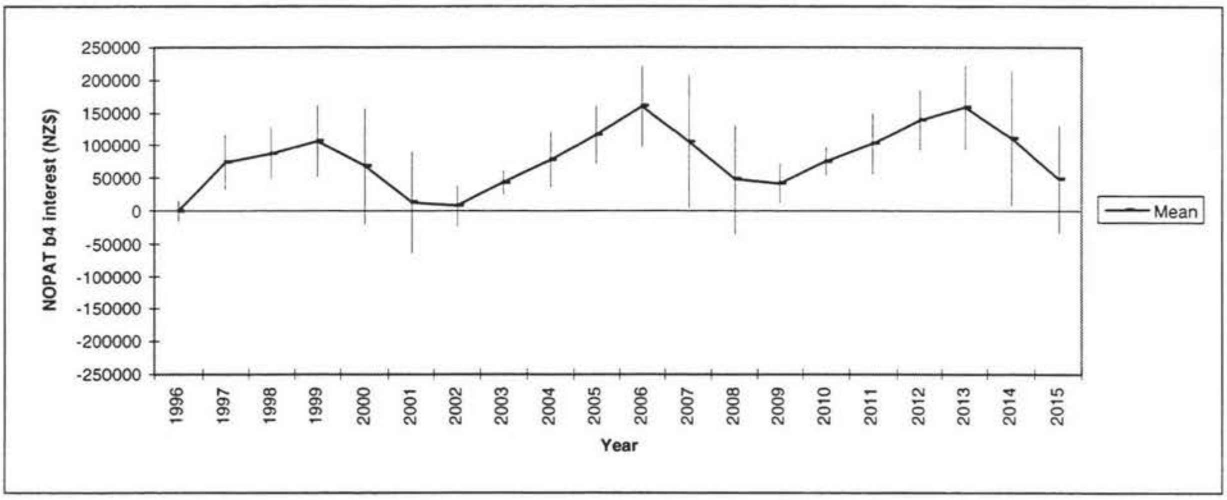

Figure 28: NOPAT before interest for the New Zealand case farm developed at 25 ha/y.

When developing 50 ha/y (Figure 29) the model predicts the farm would have a negative NOPAT for the first year of around NZ$ 25,000. The average NOPAT for the first 6 years of the project is predicted to be around NZ$ 50,000 and, when the project finishes, this increases to an average of NZ$ 95,000 with between year variation following the trend in cattle prices (Figure 25).

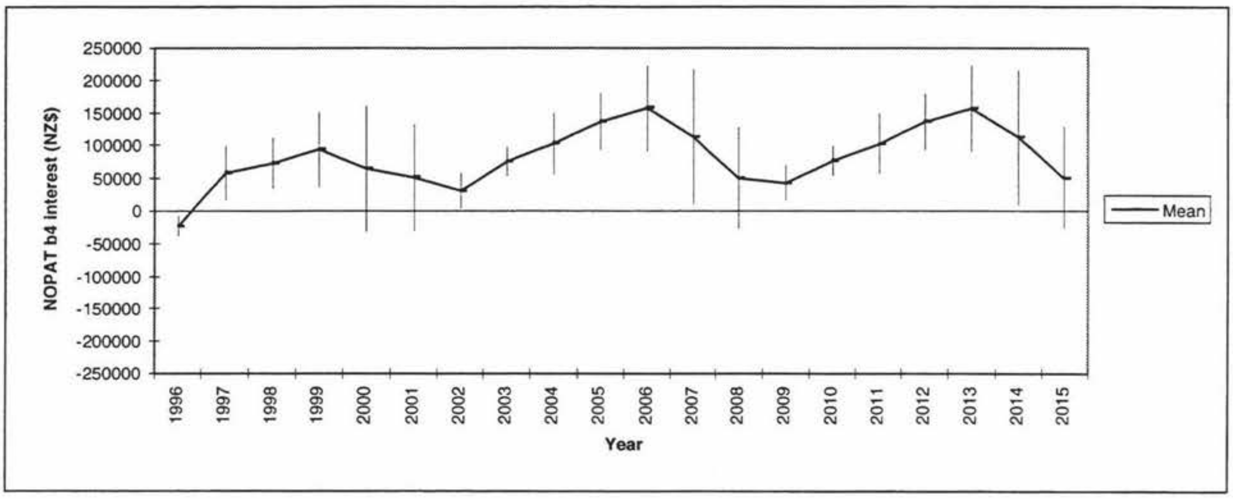

Figure 29: NOPAT before interest for the New Zealand case farm developed at 50 ha/y.

5.8.2. Discussion of outcomes

The results for the New Zealand case farm show that developing 'native' pasture into improved pasture is profitable at a 6% discount rate when production and price risk are incorporated in the analysis. Gains obtained for developing 50 ha/y or 25 ha/y are large in comparison to the status quo scenario (Figure 30 & Table 36). The 50 ha/y scenario has first degree stochastic dominance over the two other options at a 6% discount rate. The expected increase in the beef cattle schedule from the low returns of 1996 is likely to produce good returns for developing pastures and increasing production. The salvage value of the project and for the status quo (Figure 31), already incorporated in the NPV (Figure 30), do not have big influence on the NPV suggesting that the development is likely to be profitable even if the salvage value is not accounted for. For either development project (25 ha/y or 50 ha/y) the salvage value is between NZ$ 111,000 and NZ$ 170,000 and for the status quo between NZ$ 1,800 and NZ$ 2,700 (Figure 31).

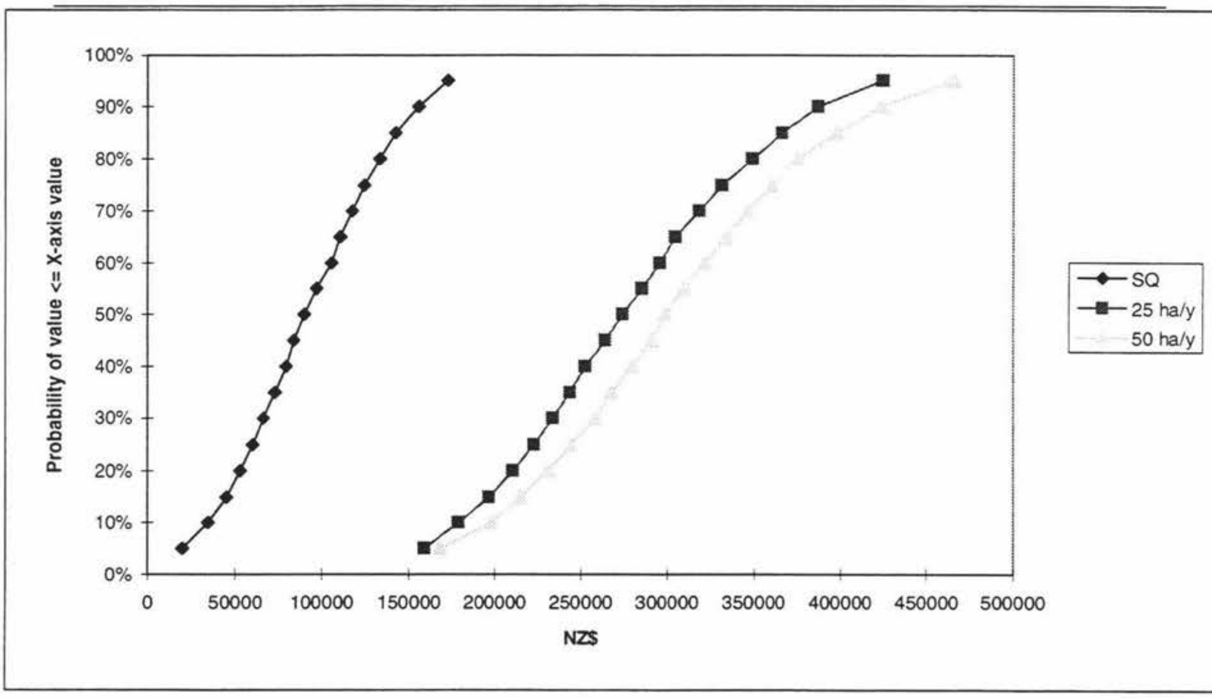

Figure 30: Probability of NPVs for the New Zealand case farm at a 6% discount rate.

Table 36: Probability of NPVs for the New Zealand case farm at a 16% discount rate.

Probability	Status quo	25 ha/y	50 ha/y
5%	20,422	159,191	168,256
10%	34,808	179,034	198,577
15%	44,639	196,481	215,375
20%	52,506	210,910	231,149
25%	60,184	223,069	244,486
30%	66,323	234,020	258,136
35%	72,946	243,564	267,935
40%	78,767	252,727	279,658
45%	83,782	263,804	290,103
50%	89,539	274,001	298,265
55%	97,243	285,190	309,532
60%	105,323	295,486	321,459
65%	110,575	304,235	333,697
70%	117,364	318,160	346,248
75%	124,682	331,268	359,690
80%	133,495	348,842	374,896
85%	142,162	365,775	398,049
90%	156,020	387,237	423,495
95%	172,386	424,697	465,751

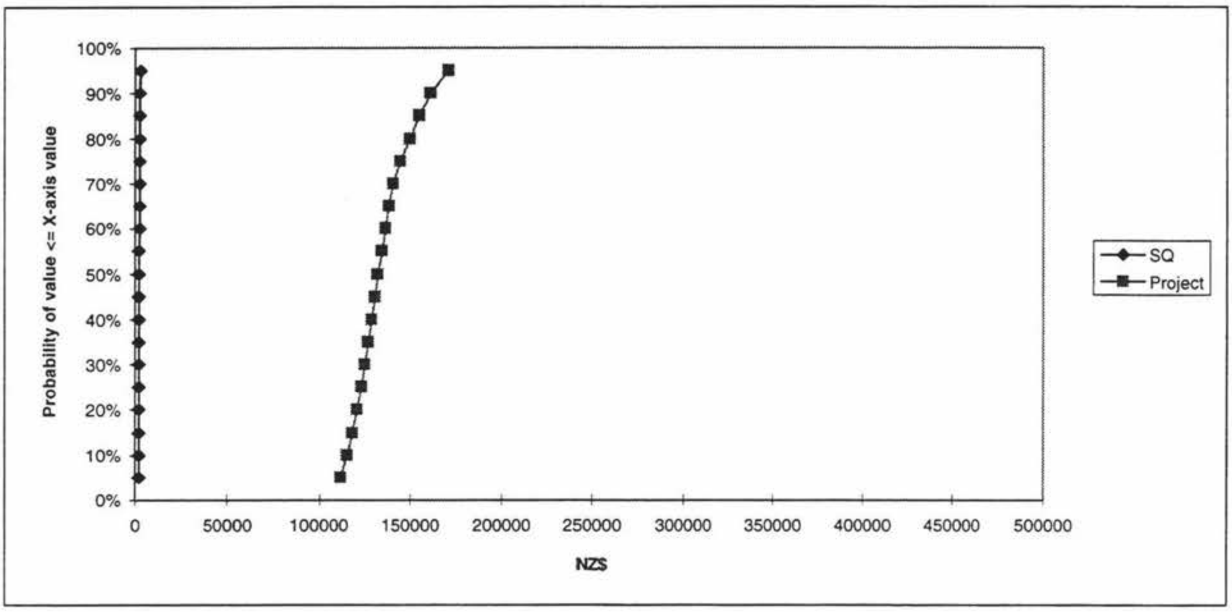

Figure 31: Probability of NPVs of the salvage value for the New Zealand case farm at a 6% discount rate.

Chapter Six: Conclusions

6.0. Introduction:

In this Chapter the conclusions from the present study are presented followed by suggestions about the ways the model could be further improved. Areas that deserve further research are highlighted.

6.1. The suitability of the spreadsheet model:

The spreadsheet software (Microsoft Excel®) together with the @Risk® software provided an easy to use interface through which stochastic simulations could be implemented. In its present form the model fulfilled the objectives of the project, by providing the required information on the profitability, feasibility and risk of a pasture development program. The software is easy to learn to use and upgrade due to the widespread adoption of spreadsheet software and the flexibility of the program language, provided that the user/programmer understands the logic behind the model.

The whole farm approach used in the model allowed the financial consequences of development for the whole system of a specific farm to be considered rather than in narrower terms in the form of a marginal analysis. The farm's cash flow, interest payments and debt situation can be modelled and this allows the farmer to gain an appreciation of the magnitude of changes to the system. The tax liability can be assessed and the influence of tax on future cash flows, which in some cases may be substantial, during the development can be analysed.

6.2. Stochastic simulation:

Stochastic simulation was used because the analysis of average values or 'what if' scenarios does not allow the farmer to visualise the variability of the possible outcomes nor to identify the critical inputs for developing the farm system. When analysing the consequence of the variability of more than one input on the final output, the impact of each input as well as its variability on system output is important.

Variation in weather conditions has a large influence on the productivity of pastoral systems. The influence is dependent on how adjusted the system is to an average year and how variable the weather is for a particular farm. The determination of a "good" and "bad" year in terms of weather can be based on the farmer's experience or from actual rainfall records and associated pasture growth rates. Until models are developed that can predict the influence of variable weather for a specific pastoral farm, farmer experience is likely to remain the best indicator of production risk.

Stochastic beef cattle prices were used in the model because changes in the beef schedule have a large impact on farm profitability. Historically, beef cattle prices have been highly variable. A Fourier curve was used to define the variation in beef cattle prices in Brazil and New Zealand because, in both countries, the use of 1996 beef cattle prices for the life of the project would have been inappropriate. In New Zealand, 1996 cattle prices were much lower than in the previous five years and the medium outlook is for prices to improve (both because of a recovery in the US market and the development of alternative markets for New Zealand beef).

At 1996 cattle prices, farm development for the New Zealand case farm was not financially sustainable. On the other hand, beef cattle prices in Brazil during 1996 were higher than the historical prices and closely followed a typical six year trend for the Brazilian internal market. Thus, the profitability of development for the Brazilian case farm would probably be overestimated if the 1996 beef cattle prices were used for the entire development period. The use of predicted future values in the current study and the likely probability of these being realised, therefore represents an important advance on earlier farm development models.

Stochastic computer models are likely to become a more important source of information for farmers and consultants because they provide additional insight into the consequences of alternative management decisions. The further freeing-up of agricultural markets and the removal of agricultural support increases the need to formally and carefully consider risk. Universities and research institutions are likely to the most important sources of such models because of the time and expertise needed for their construction and evaluation. The computer model developed in this thesis illustrates that information about business risk can be obtained and used to develop farm specific recommendations.

6.3. Further improvements to the present model:

The present model could be improved by adding options such as a dairy conversion, forestry, cropping or buying/leasing an additional area of land. Stochastic investment analysis of these development options could show greater influence of risk than in the case of the pasture development. Stock classes other than beef cattle could be utilised in the present model to predict economic returns for pasture development on farms with livestock enterprises other than beef cattle. In addition, the present model could be improved by programming it in a more sophisticated computer language. This would be more time consuming and expensive than the present spreadsheet version, but the software would run faster and could be customised as a stand alone package.

6.4. Areas for further research:

Two important components of the present model are presented as areas for further research in New Zealand. First, the accurate modelling of the biological components of the farm system. Pasture growth, pasture quality and animal performance needs to be modelled in terms of the measurable variables easily obtained for specific farms such as weather variables, soil fertility, botanical composition and stocking rate, and incorporated into stochastic models so that the probability distributions for pasture growth and animal performance can be obtained. Second, improved techniques for forecasting long-term trends in market price for animal products would help on the assessment of the financial value of the extra production obtained from the improved pastures.

In Brazil, the same areas are in need of further research but, in the Brazilian case, even fewer data are available than in New Zealand. The assessment of average monthly pasture growth rates for different regions would be an useful starting point. At present very little data are available on pasture growth rates. Forecasting of market prices and interest rates is another critical factor when analysing long-term investments in Brazil because of the more uncertain economic situation than in New Zealand. Finally, the effective diffusion of information from Brazilian research institutions and universities to the farmer needs special attention.

6.5. Conclusion:

In New Zealand and southern Brazil farmers have to make decisions, with imperfect knowledge, that are not easily reversible without a significant monetary loss. The model presented in this thesis generates information for the farmer on the likely results of the decision so that s/he can assess the overall picture of how decisions will affect farm profitability in the long-term.

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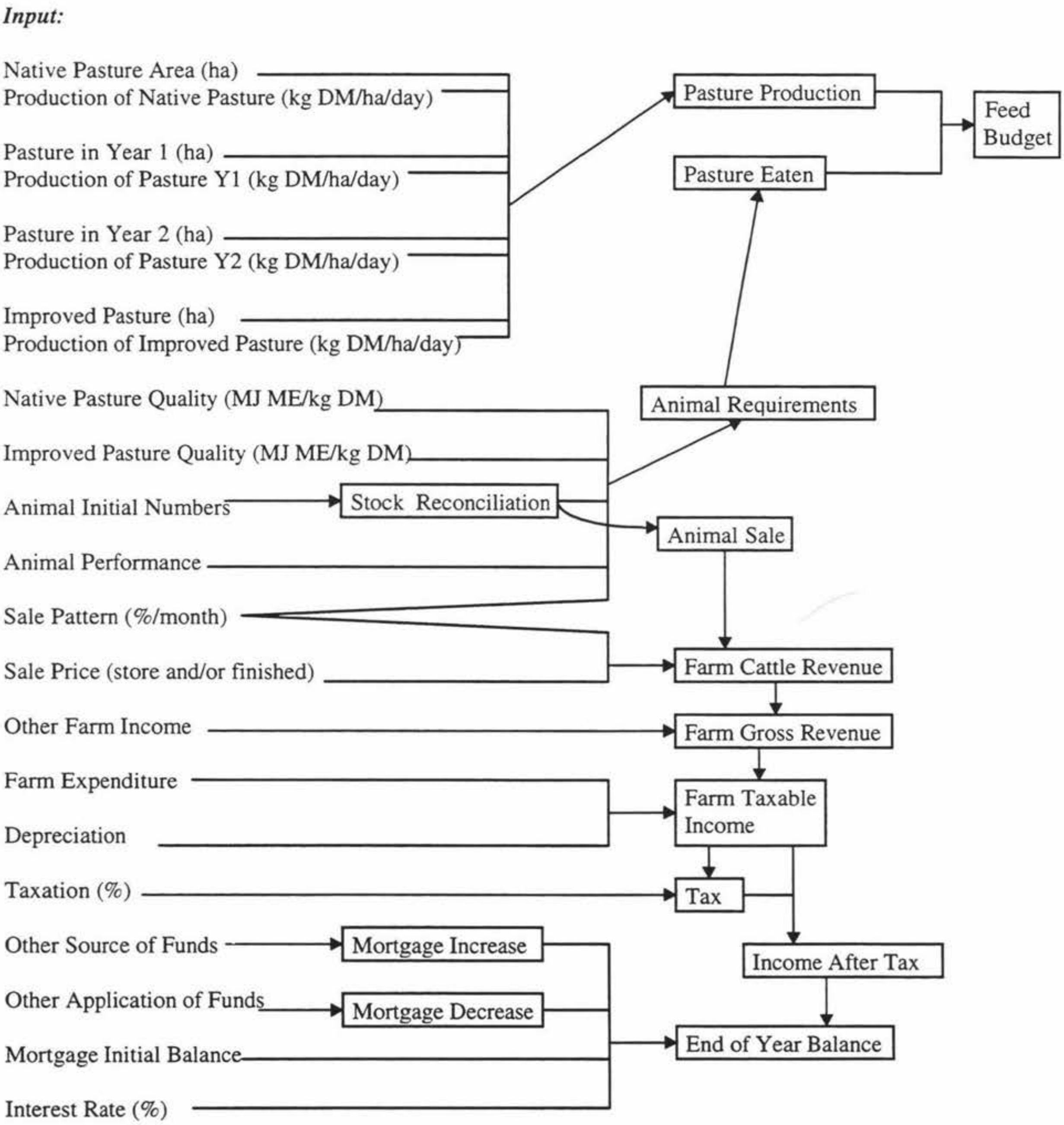
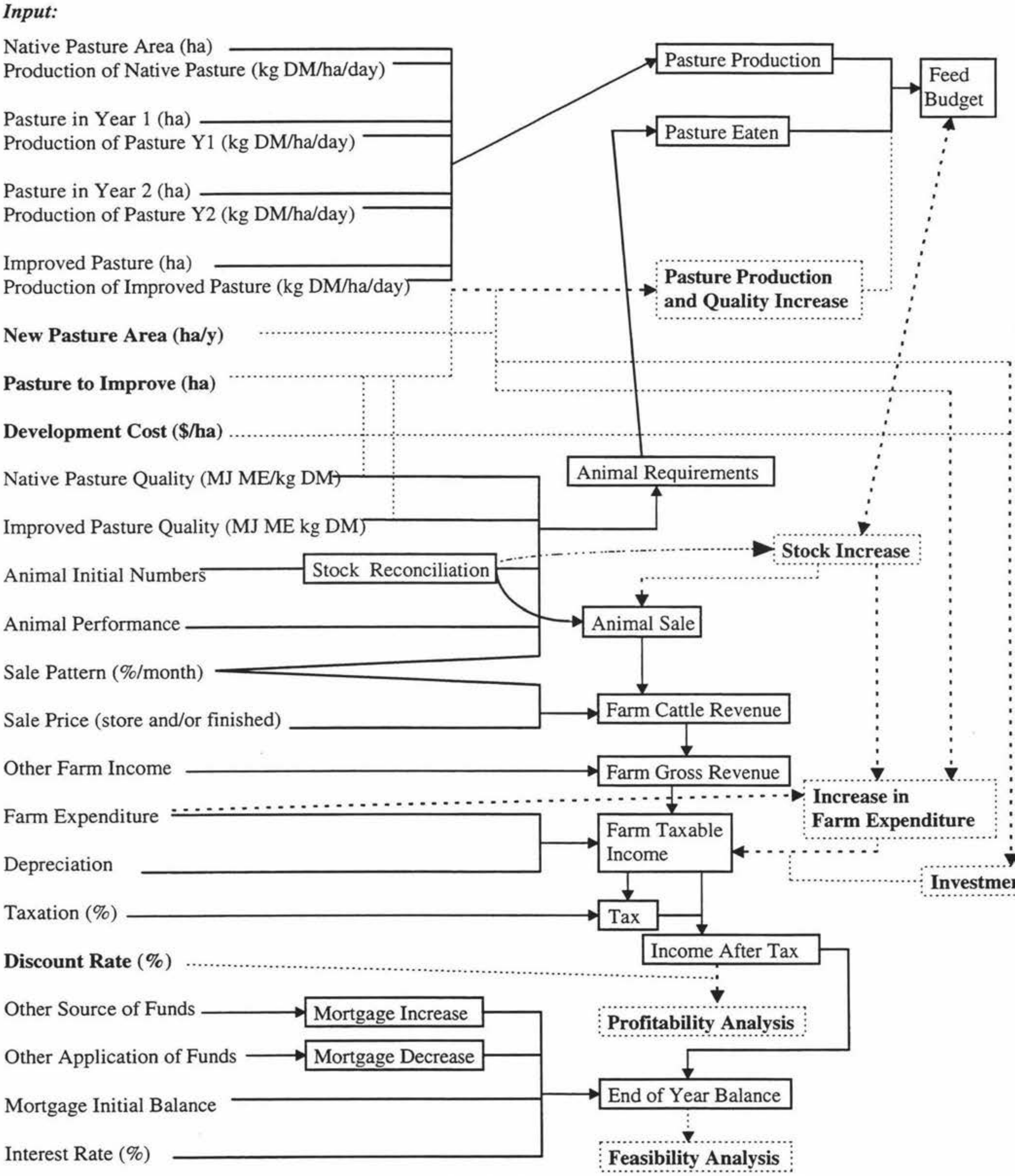
Appendix



Appendix I: Model inputs for defining the status quo situation on a case farm.



Appendix II: Inputs necessary to run a deterministic simulation for a case farm development option (in bold) and their relationship to model components (see Appendix I).

Year	Historical	Mean	st dev.
1976	0.98	0.74	0.01
1977	0.96	0.75	0.03
1978	1.31	0.76	0.05
1979	1.56	0.61	-0.02
1980	1.21	0.56	-0.02
1981	0.93	0.69	0.03
1982	0.76	0.74	0.01
1983	0.69	0.75	0.03
1984	0.72	0.76	0.05
1985	0.58	0.61	-0.02
1986	0.83	0.56	-0.02
1987	0.73	0.69	0.03
1988	0.71	0.74	0.01
1989	0.81	0.75	0.03
1990	0.81	0.76	0.05
1991	0.63	0.61	-0.02
1992	0.57	0.56	-0.02
1993	0.63	0.69	0.03
1994	0.76	0.74	0.01
1995	0.75	0.75	0.03

Appendix III: Historical data for beef cattle prices in Brazil and prices predicted by the fitted Fourier curve.

The historical data series is NZ$/kg of liveweight received by the producer in the Rio Grande do Sul state in Brazil (Nakame, 1996). The prediction equation is explained in the methods chapter and it was fitted to the period of 1982 to 1995. The year 1986 was considered 'outlier' because of overvaluation of the Brazilian currency under the 'cruzado' economic plan (Baer, 1995).

Appendix IV: Monthly rainfall and average evapotranspiration (ETP) data for the Brazilian case farm's region.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1913	50	109	86	26	99	87	105	121	94	77	68	82	1004
1914	245	73	211	198	92	252	349	128	244	252	243	184	2471
1915	153	181	193	178	340	34	46	63	188	71	155	66	1668
1916	69	114	62	38	145	66	243	88	109	19	31	84	1068
1917	30	97	97	34	4	15	24	41	60	9	23	78	512
1918	167	92	67	106	236	108	134	22	361	61	174	87	1615
1919	81	145	71	110	81	115	360	101	94	127	126	104	1515
1920	43	157	96	127	102	262	72	63	108	102	72	231	1435
1921	126	49	123	49	112	230	20	111	95	38	54	45	1052
1922	121	76	62	93	130	187	40	194	153	58	46	78	1238
1923	129	100	32	205	51	52	188	200	129	48	139	169	1442
1924	34	42	131	148	30	75	79	156	81	3	32	7	818
1925	156	96	96	101	288	1	28	195	193	121	26	86	1387
1926	37	105	50	92	119	261	226	116	133	117	180	91	1527
1927	46	68	48	179	71	206	130	112	276	202	111	97	1546
1928	121	191	68	182	175	185	136	77	236	137	35	159	1702
1929	39	47	122	1	107	132	98	135	114	226	10	180	1211
1930	89	92	196	119	162	316	74	252	67	69	136	89	1661
1931	277	15	80	106	149	146	60	75	22	30	161	78	1199
1932	11	128	215	195	235	51	94	124	127	125	71	48	1424
1933	49	167	55	40	27	84	127	75	102	82	18	101	927
1934	107	210	183	91	125	177	30	112	140	165	131	44	1515
1935	86	132	91	65	33	153	49	64	66	181	17	279	1216
1936	116	53	149	179	324	203	62	94	38	241	43	188	1690
1937	6	236	87	23	69	90	174	239	184	91	99	18	1316
1938	278	50	177	46	9	80	22	49	3	3	122	4	843
1939	55	45	15	120	60	203	14	217	72	183	75	15	1074
1940	151	39	56	180	261	115	209	107	163	261	189	206	1937
1941	230	157	33	352	195	68	108	393	46	49	90	67	1788
1942	76	84	131	101	243	145	88	126	25	121	19	7	1166
1943	9	102	74	2	185	116	138	29	96	23	135	21	930
1944	239	46	125	54	22	90	5	81	81	226	42	51	1062
1945	17	66	18	62	38	59	73	129	148	71	157	102	940
1946	42	87	81	32	112	122	111	128	99	179	117	140	1250
1947	95	223	34	88	136	107	101	37	252	83	29	113	1298
1948	89	54	50	312	312	116	148	21	342	113	106	26	1689
1949	83	38	226	91	41	92	96	94	159	264	36	76	1296
1950	36	87	117	98	122	184	117	59	93	61	22	59	1055
1951	97	120	214	76	65	115	5	68	130	71	75	74	1110
1952	9	74	215	72	213	129	171	120	106	175	30	31	1345
1953	126	3	117	92	128	149	68	82	306	94	24	27	1216
1954	247	105	39	81	58	197	212	118	189	53	46	55	1400
1955	86	186	87	168	240	36	51	23	51	37	11	70	1046
1956	190	104	130	64	24	18	53	74	141	185	37	54	1074
1957	69	18	34	67	59	185	87	109	76	249	103	94	1150
1958	99	137	36	59	108	182	109	116	134	152	106	105	1343

Appendix IV (continuation).

1959	115	78	71	576	161	102	77	194	113	222	13	98	1820
1960	133	31	128	58	25	117	297	159	190	113	68	60	1379
1961	112	121	161	74	34	156	153	72	312	178	130	154	1657
1962	59	106	84	101	5	19	95	75	259	106	34	50	993
1963	231	124	115	52	67	33	142	98	280	401	179	74	1796
1964	17	90	123	74	25	67	26	159	88	67	37	137	910
1965	21	26	133	238	54	105	30	266	274	161	68	256	1632
1966	81	148	217	134	21	190	379	133	140	183	77	258	1961
1967	79	87	23	57	177	203	158	288	229	178	67	67	1613
1968	40	24	256	85	42	51	79	15	163	126	132	195	1208
1969	101	149	42	10	124	69	89	162	67	80	119	67	1079
1970	77	121	141	27	84	232	103	151	56	133	61	176	1362
1971	224	235	41	11	100	88	95	98	76	87	34	97	1186
1972	88	45	113	45	111	228	247	212	151	180	148	45	1613
1973	178	358	40	181	117	101	207	71	62	124	24	112	1575
1974	111	107	142	42	67	115	136	157	142	61	111	131	1322
1975	86	79	99	16	107	73	61	154	191	66	175	48	1155
1976	183	50	167	116	75	48	134	136	88	108	128	123	1356
1977	188	187	99	210	132	149	507	53	81	204	120	31	1961
1978	89	44	76	59	83	106	177	41	63	112	87	46	983
1979	23	89	67	125	11	35	80	156	231	133	102	201	1253
1980	20	93	240	174	41	224	96	54	28	265	188	101	1524
1981	139	187	42	74	195	110	112	36	151	43	103	110	1302
1982	88	211	43	27	147	117	185	181	170	181	173	100	1623
1983	113	461	70	69	162	120	230	83	128	95	109	78	1718
1984	217	133	69	198	301	205	158	67	130	145	67	44	1734
1985	43	39	242	170	191	153	87	157	141	70	9	36	1338
1986	158	86	215	155	285	63	63	169	101	156	364	7	1822
1987	251	58	217	248	141	50	228	242	190	58	114	182	1979
1988	237	57	96	50	27	83	55	70	203	57	92	26	1053
1989	156	1	81	105	17	13	45	113	87	48	79	54	799
1990	37	460	293	139	87	14	71	28	196	116	227	155	1823
1991	45	16	108	532	117	104	144	13	67	157	119	193	1615
1992	132	183	110	461	184	206	169	74	127	99	24	77	1846
1993	305	54	17	86	359	180	133	24	33	173	169	287	1820
1994	111	189	138	95	98	121	213	103	63	180	67	129	1507
1995	51	162	109	85	128	90	373	36	114	132	49		
ETP	**137**	**106**	**89**	**51**	**32**	**21**	**26**	**41**	**72**	**88**	**113**	**137**	**913**