INTEGRATING FINANCIAL AND ENVIRONMENTAL DATA TO IMPROVE FARM BUSINESS PERFORMANCE: AN EXPLORATORY ANALYSIS OF THE TASMANIAN BEEF INDUSTRY

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Statement of Originality

The work in this thesis is, to the best of my knowledge and belief, original except where acknowledged in the text. The author hereby declares that the contents of this thesis have not been submitted, either in whole or in part, for a degree of any kind at this or any other academic institution.

Sarah Gatenby

October 2010

Statement of Authority

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Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

Sarah Gatenby

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List of Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ALUM	Australian Land Use and Management
ANRA	Australian Natural Resources Atlas
ASC	Australian Soil Classification
BRS	Bureau of Rural Science
COP	Cost of Production
CRCSI	Cooperative Research Centre for Spatial Information
CRES	Centre for Environmental Research and Environmental Studie
DAFF	Department of Agriculture, Forestry and Fisheries
DEWHA	Department of Water, Environment, Heritage and the Arts
DNRD	Do Not Read Down
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DSE	Dry Sheep Equivalent
dwt	Dressed Weight
EBA	Effective Beef Area
Equity%	Equity Percentage (4 Year Average Values)
EVAO	Estimated Value of Agricultural Operations
FDE	Farm Dependent Economy
FTE	Full Time Equivalent
GDP	Gross Domestic Product

GIS	Geographic Information Systems
GOE	Gross Operating Expenses
GPS	Global Positioning System
GSP	Gross State Product
ha	Hectare
IRIS	Infrastructure and Resources Information Service
kg	Kilogram
KPI	Key Performance Indicator
LIST	Land Information Systems Tasmania
lwt	Liveweight
MLA	Meat & Livestock Australia
NELUP	National Environmental Resource Council-Economic and Social Research Council Land Use Programme
NRM	Natural Resource Management
NLWRA	National Land and Water Resources Audit
OP	Operating Profit
PID	Property Identification Number
RD	Read Down
RIRDC	Rural Industries Research and Development Corporation
RMIT	Royal Melbourne Institute of Technology
ROA	Return on Assets
ROA_{CG}	Return on Assets Including Capital Gains
ROC	Return on Capital

ROE	Return on Equity
ROE_{CG}	Return on Equity Including Capital Gains
SR	Stocking Rate
TE	Technical Efficiency
TFP	Total Factor Productivity
TIAR	Tasmanian Institute of Agricultural Research
UK	United Kingdom
USA	United States of America
USDA	United States Department of Agriculture
UTAS	University of Tasmania

Abstract

The Tasmanian beef industry is currently under pressure as a result of factors such as declining terms of trade, increased competition from other enterprises, degradation of grazing land, drought, and rising costs of inputs to production. These issues significantly affect the long-term viability of the industry, and highlight the need for improved understanding of the relationships between agricultural productivity, profitability, and the biophysical capacity of the land. This thesis considered key productivity and profitability drivers of beef production in Tasmania through the integration of farm financial and biophysical data. The aims were:

- To identify the key factors affecting productivity and profitability of beef production
- To examine the utility of Geographical Information System (GIS) and spatial modelling for analysing and integrating financial and environmental data relevant to assessing farm business performance
- To use case studies to investigate relationships between farm business performance and farm biophysical attributes in the beef industry
- To consider GIS and spatial modelling applications that may be suitable for decision support and scenario analysis in livestock industries.

Farm financial data for the 2006/2007 financial year of 27 beef enterprises were obtained through a financial benchmarking process. Additional data relating to enterprise management were also collected using a questionnaire. Biophysical data for each property were derived using GIS technology. Data from each enterprise were integrated and statistically analysed to identify correlations between financial performance and biophysical capacity of the land. To gain an understanding of how well the enterprises represented the State-wide industry, and to map landscapes suitable for

supporting profitable beef enterprises in the state, GIS was also used to characterise the overall beef industry in Tasmania.

Building on this exploratory analysis, case studies were used to study in more detail the relationships between financial, biophysical and management data at an enterprise level. Based on Australian Bureau of Statistics protocols, additional information relating to management philosophy, environmental assets and natural resource management was collected for these enterprises. Examining the correlations from the exploratory analyses, and information from the case studies in conjunction with the landscape mapping and characterisation of the Tasmanian beef industry, the suitability of this technique as a decision support and scenario analysis tool was considered.

Analysis of the financial data has shown significant variation in the productivity and profitability of Tasmanian beef enterprises. Statistical analysis of the financial data with the biophysical data identified a number of correlations. The proportion of land that is improved pasture, the proportion of relatively high or low fertility soils and the efficiency of beef production (Kg/ha) were strongly related to the profitability of an enterprise. Reduced risk, through increased operating profit margin and reduced cost of production, were explained in part by increased efficiency of beef production and land area. Stocking rate was strongly correlated with biophysical attributes that influence pasture production - in particular, area under irrigation, long term rainfall and air temperature.

This project has shown GIS and spatial modelling to be an effective method for identifying statistically significant biophysical variables that help explain the performance of beef producing enterprises in Tasmania.

1. Introduction

1.1 The beef industry in Australia needs decision tools to support sustainable productivity improvements

Agricultural production is an important component of Australia's economy, contributing 2% (over $18 billion) to the gross domestic product (GDP), and employing around 359,000 people (ABARE 2009a). The total contribution that agriculture makes to the economy, including the manufacturing and service sectors that utilise farm outputs, is referred to as farm dependent economy (FDE). The Australian FDE is around 12% of the national GDP. In Tasmania the FDE contribution to the Gross State Product (GSP) is around 16%; a figure that is proportionally more than any other Australian State and Territory FDE (Davey & Maynard 2005; IRIS 2008).The livestock industry accounts for more than 45% of Australia's total value of agricultural production (Nossal *et al.* 2008). There are estimated to be 25.4 million head of beef cattle in Australia that are raised on around 219.7 M ha of land. Australian cattle production is worth approximately $7.5 billion per annum (Nossal *et al.* 2008; USDA 2008). Beef production therefore is a significant feature of Australia's economy and environment.

The Australian beef industry is faced with a range of challenges including global political and economic fluctuations, droughts, trade barriers, global competition, disease eradication, competition from other enterprises for land and resources, and consumerism (Bindon & Jones 2001). For example, the majority of beef produced in Australia is destined for international markets. From 1988-89 to 2007-08 exports of beef have increased from 53% to 64% of total beef produced, this equates to 1.4 million tonnes of the 2.1 million (carcass weight) tonnes produced being exported (DAFF 2007; Nossal *et al.* 2008; USDA 2008). However, such a high proportion exported means that the industry is strongly influenced by the movements of international markets and the fluctuations in the value of the Australian dollar (MLA 2008). As a result, producers require ongoing improvements in productivity to maintain or improve beef industry profitability and international competitiveness.

Productivity is a measure of the ability to produce goods and services (outputs) given the available resources (inputs). Over recent years, the price received for cattle has been reasonably strong. However, relative to the price of farm inputs, cattle values have declined over the longer term (Nossal *et al.* 2008). Penm and Glyde (2007) argued that the factors that can significantly influence agricultural productivity are more diverse than have been reported in most research. Improved understanding of the relative importance of factors affecting farm productivity is therefore essential for delivering continuous productivity improvements. Productivity gains can be achieved with the use of new technology and better farm management practices that increase output and/or reduce inputs or both (Nossal *et al.* 2008). However, these gains also must be achieved in an environmentally sustainable manner to ensure ongoing productive and responsible environmental stewardship. To do so farmers need to be able to make management decisions that better integrate the goals of productivity improvement and sustainable resource use.

Management choices are generally made using the best information available to the producer at the time. Improved access to quality information can enhance the capacity of farm enterprises to assess management options and identify the potential consequences of different decisions. Information on the biophysical capacity of the land base under different management options is important. Benchmarking and geographic information system (GIS) tools can be used to obtain information and help evaluate the most suitable management options. Utilising such tools may improve the understanding of producers about their enterprise and enable them to make more effective decisions to enhance productivity, profitability and sustainability.

1.2 Thesis Aims

This thesis describes an exploratory analysis aimed at identifying the key factors affecting productivity and profitability of Tasmanian beef production, and assesses a technique to integrate financial and environmental data.

The aims of this thesis were:

- To identify the key factors affecting productivity and profitability of beef production
- To examine the utility of GIS and spatial modelling for analysing and integrating financial and environmental data relevant to assessing farm business performance
- To use case studies to investigate relationships between farm business performance and farm biophysical attributes in the beef industry
- To consider GIS and spatial modelling applications that may be suitable for decision support and scenario analysis in livestock industries.

1.3 Approach to Thesis

The thesis was based on an exploratory analysis of the Tasmanian beef industry and included several individual case studies. Case studies were used to investigate the relationships between financial and environmental data on farm business performance at an enterprise level. The exploratory analysis provided an overview of the wider industry, whilst the use of case studies allowed a more detailed analysis of enterprise management practices. Following a literature review of the subject areas in Chapter 2, Chapter 3 sets the scene by providing an overview of the Tasmanian beef industry. Chapter 4 and Chapter 5 examine various relationships between farm business performance and farm biophysical attributes in the industry. The major findings, implications and directions for future research are outlined in Chapter 6.

2. Review of literature

2.1 The beef industry

2.1.1 The beef industry in Australia and Tasmania

The production of food and fibre from agriculture is an important part of Australia's economy. Agriculture (including forestry and fisheries) accounts for 2% of the nation's $922.4 billion GDP (ABARE 2008a). Australian cattle production is worth approximately $7.5 billion (USDA 2008; ABARE 2009a). Approximately 2.1 million tonnes (carcass weight) is produced annually, and of this nearly 1.4 million tonnes is exported each year (USDA 2008; ABARE 2009a). Australia is the world's second largest exporter of beef (USDA 2008) and the prospects of the industry can be heavily influenced by international market fluctuations.

In Australia, the beef industry is geographically extensive and spans a climatically-diverse range of environments comprising 219.7 million ha of land. Seventy two per cent of the land area used by the industry is located in northern Australia (the Northern region) whilst the remaining 28% of the land base occurs in southern Australia and is classified as Southern beef production (ANRA 2007). The different beef producing regions are illustrated in Figure 2.1. Northern beef production occurs in northern Queensland, the Northern Territory and the pastoral zones of Western Australia, and accounts for well over half the total cattle numbers in Australia, with approximately 16 million (out of 25.5 million) head of cattle (Kannapiran 2001; ABARE 2009a). Northern beef production is characterised by larger properties, with grazing of predominantly native pastures at very low stocking levels (Kannapiran 2001; ANRA 2007; Nossal *et al.* 2008). Cattle produced from the northern region are generally destined either for export to the United States of America (USA) for lot-feeding or as live exports to other regions of the world (Kannapiran 2001).

Southern beef production involves smaller properties, with a higher proportion of introduced pasture and fodder crops. These enterprises are managed and grazed more intensively (Kannapiran 2001; ANRA 2007; Nossal *et al.* 2008). The southern region generally supplies smaller, younger cattle, chiefly for the domestic market, and higher quality stock for the Japanese market (Kannapiran 2001).

The study reported in this thesis focuses on Southern beef production, in particular the Tasmanian beef industry. Red meat makes up nearly 40% of the gross value of all animal industries in Tasmania (DPIW 2007). Tasmanian beef production had a gross value in 2006-07 of $172 million, constituting 18% of the State's gross value of agricultural production, and contributing 2% to total gross value of Australian beef production (DPIW 2007).

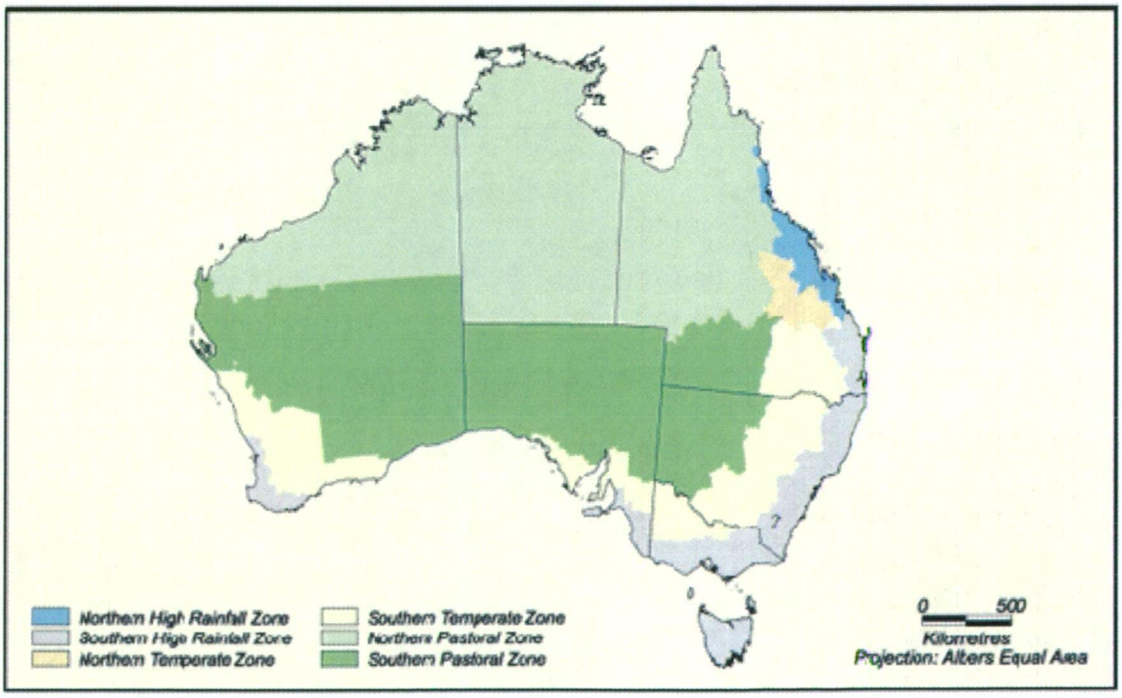

Figure 2.1 Regions of beef production in Australia (Source: ANRA 2007)

The two primary markets for processed Australian beef are domestic consumers and export markets (Bindon & Jones 2001; Kidane 2003). The general structure of the Australian red meat industry (not including live export) is shown in Figure 2.2. Annually, 500,000-600,000 live cattle, valued at $350 million are exported from Australia. The majority (70%) of these cattle are exported from Western Australia and the Northern Territory, with Indonesia being the largest live export market accounting for 55-60% of the trade. Australian domestic consumption of beef in 2007 accounted for 775,000 tonnes, equating to a consumption of around 37 kg per person. This is expected to remain steady with an increase to 850,000 tonnes (or 37.4 kg per person) forecast by 2012 (MLA 2008). However, viable export markets are crucial to the Australian and Tasmanian beef industry. In 2008 the total amount of beef and veal exports from Australia was 1.36 million tonnes (carcase weight) with a value of $4,170 million. The majority (64%) of beef produced was exported. Japan and the USA accounted for 41.4% and 31.1% (Figure 2.3) of the total exports, respectively (DAFF 2007).

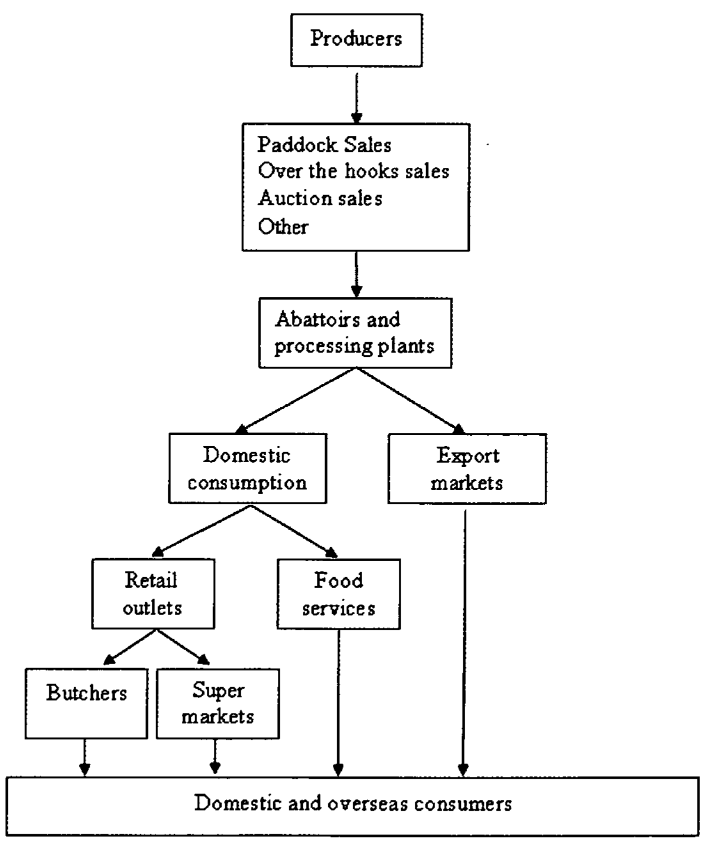

Figure 2.2 Diagrammatic representation of the structure of the Australian red meat industry. Adapted from Bindon & Jones (2001) and Kidane (2003)

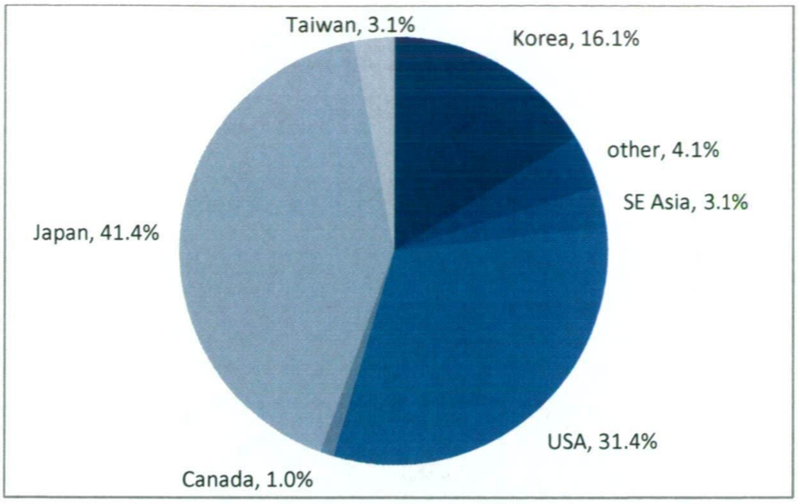

Figure 2.3 Australian beef export markets, (adapted from DAFF 2007)

2.1.2 Issues and challenges

In the 1930s the development of technology enabling shipping of chilled beef from Australia to the United Kingdom (UK) triggered the beginning of what is now a multi-billion dollar export industry. Since then many domestic and global events, such as droughts, world wars, economic depressions, food safety, Government policy, consumerism and beef quality, have impacted on the Australian beef industry and beef marketing (Bindon & Jones 2001). Following each major impact to the Australian beef market, in response there have been modifications to production systems, breeding programs, herd structure, processing procedures, advertising and promotion, meat retailing and end-use (Bindon & Jones 2001). For example, in the mid 1980s, there was a reform of the Australian Meat and Livestock Corporation to try and counteract the negative impact that a decline in domestic beef consumption was having on the industry. This reform changed the meat industry from being 'production-driven' to 'consumer-driven' (Bindon & Jones 2001). This indicates the flexibility of the industry and the potential responsiveness of Australian beef producers to changing marketing environments. At present, Australian beef producers are being put under continued pressure by sustained declines in terms of trade, rising input prices, pressures of climate change and a declining resource base (Nossal *et al.* 2008).

Australian cattle numbers fluctuate due to market forces such as drought, low wool prices, market failure from over-supply, and the influence of cattle production in competing nations overseas (Bindon & Jones 2001).

Climate and drought

Current beef cattle numbers throughout Australia are relatively steady at around 25.5 million (ABARE 2009a). Despite the severity of the current drought in southern Australia the impact on the national herd numbers has been minimal. This has been largely due to favourable conditions in most of northern Australia and, to some extent, the adoption of on-farm drought management strategies (ABARE 2007, 2008a).

Supply and demand changes

Recent cattle prices have been historically high. This situation has resulted in higher returns from export markets, and increased competition for supply amongst processors, lot feeders and re-stockers. Despite continued high saleyard prices and strong export markets, the average farm cash income and business profit has been reduced due to factors such as rising input prices and the financial impacts of the recent severe drought in southern Australia (Bailey *et al.* 2004; MLA 2008).

Due to the high proportion of meat exported from Tasmania, the future size and productivity of the State's beef industry will be strongly influenced by demand for beef in the international market, and the relative profitability of other enterprises that compete for the available agricultural resources. Tasmania's ability to gain and secure interstate and overseas market share through effective product differentiation - as well as achieving continued productivity growth and secure access to resources (eg. land, water) - will also have a strong influence on the long term outlook for Tasmania's agricultural sector (IRIS 2008).

Enterprise competition

Over recent years in Tasmania, there has been a significant reduction in the area of land dedicated to beef production as a result of changed land use. In particular, changes in land use to increased tree farming and the rezoning of land for urbanisation has reduced the land resource for livestock industries (DPIW 2007). Continuation of this trend may compromise the Tasmanian beef industry's long-term viability due to a loss of industry-level economies of scale. There is an opportunity for producers and industry to compensate for loss of land area by increasing the productivity of the remaining areas used for beef production (DPIW 2007). Improvements in pasture growth and utilisation are important factors in maintaining productive, profitable beef production - in particular, through increasing live weight (lwt) production of beef cattle per hectare. Improving the integration of meat production into irrigated cropping enterprises (mixed farming systems) and improving the performance of feedlot finished steers are other opportunities for the Tasmanian beef industry (DPIW 2007).

The future prospects for the Australian and Tasmanian beef industry will depend largely on the ability of producers to effectively manage current and emerging issues and challenges. This ability will be improved by the development of decision support tools that provide relevant, integrated information in these complex production environments.

2.2 Evaluating Farm Business Performance

2.2.1 Introduction

Traditional farm management economics uses a mix of disciplinary knowledge about human, technical, economic, financial risk and institutional aspects of a particular farm business to analyse the resources available, the potential opportunities and the constraints (Malcolm & Ferris 1999). Successful farm management requires knowledge and understanding of the profitability and productivity drivers of an enterprise. There are a range of different approaches that can be used to provide baseline information, evaluate performance and identify areas of potential productivity gains to help improve business performance in the beef industry. Some of these approaches are outlined in 2.2.2.

2.2.2 Farm business performance measurement

Farm business performance can be reported in a number of ways including Estimated Value of Agricultural Operations (EVAO), Total Factor Productivity (TFP), Technical Efficiency (TE), Key Performance Indicators (KPIs) and cost of production (COP).

EVAO is a measure of gross farm income, but not necessarily an indication of enterprise profitability. EVAO is correlated with enterprise size and is often a better measure of the scale of a farm business than farm area (Cary *et al.* 2002). EVAO is commonly used by the Australian Bureau of Statistics to classify the size of agricultural operations (ABARE 2008b).

TFP measures overall productivity by comparing a ratio of total outputs relative to total inputs used in the production of those outputs (Knopke *et al.* 1995; Nossal *et al.* 2008; Zhao *et al.* 2008). TFP is a useful summary indicator for monitoring and analysing the performance of farm business and industries. Scale of production, intensity of operations and turnover can all be measured by using TFP (Fleming *et al.* 2006; Tocker 2006; Nossal *et al.* 2008; Zhao *et al.* 2008).

TE indicates how well producers use inputs to generate outputs based on a best practice farm. TE can be used to assess an individual producer's efficiency relative to that of best practice farmers (Fleming *et al.* 2006; Geenty *et al.* 2006; Tocker 2006). TFP is a more comprehensive measure then TE as it incorporates differences between farms in production technology. In comparison, methods used to estimate TE assume a constant production technology across all farms in the sample. TE, technical change (where those that are technically efficient have increased or declined in TE) and TFP are additional benchmarking tools that enable comparisons to be made between years and against other businesses.

KPIs are underlying factors that determine the potential profitability of a business. KPIs vary depending on the business type; in beef production KPIs can include stocking rate (SR), labour efficiency and quantity of beef produced per hectare (ha) (Newman & Chapman 2001; Holmes *et al.* 2005). KPIs are discussed in more detail later in this Chapter.

COP is a description of the cost involved in producing one unit of product. In beef production COP refers to the cost to produce 1kg lwt of beef and includes costs such as labour, feed and overheads (MLA 2005). COP information is essential for good business management especially for analysis of profitability and identifying potential areas of expansion (Newman & Chapman 2001). Holmes *et al.* (2004) identified COP as having a major impact on farm profitability. Having an understanding of the costs associated with production of an enterprise and the factors determining these costs can allow producers to better manage their enterprises in times of adversity. For example, if the COP for an enterprise is sufficiently low the enterprise may remain profitable even when product prices are relatively low (Holmes *et al.* 2004).

Whilst all of these farm performance measures have some advantages, there is however one method that can incorporate most of these measurements whilst providing a quantitative analysis of enterprise performance that can be used to compare performance between years or between enterprises. This is farm financial benchmarking.

2.2.3 Benchmarking

Benchmarking is an activity-based analytical method described as "a process of effective decision making that results in continuous improvement of management 'practices' and operating 'processes' within the business"(RIRDC 2000). Benchmarking is the process by which performance indicators and enterprise productivity values are identified, measured and compared. Farm financial benchmarking is a management tool that can assist farmers in improving the productivity and profitability of their enterprise and can be of benefit to individual producers as well as the industry as a whole (Johnstone 1999).

Benchmarking practices have been in use since at least 1907 when the company BHP is believed to have compared its steel manufacturing performance in Australia with steel makers in Europe (AusIndustry 1993). In the late 1970s the company Xerox conducted a benchmarking study to compare its production in the USA with their Japanese affiliate Fuji Xerox. Findings from that study resulted in the initiation of a successful plan to reduce costs in the US manufacturing processes. As a result of the success of this initial program, Xerox management incorporated benchmarking as a key element in their business improvement efforts (AusIndustry 1993). The use of benchmarking practices by Xerox is often regarded as one of the pivotal moments in the widespread adoption of benchmarking practices throughout the world (Cox *et al.* 1997).

Currently the process of benchmarking is used as the primary method of performance analysis in a wide range of public and private sectors where it has been proven to have been instrumental in assisting the transformation of unproductive operations into efficient, profitable ones (AusIndustry 1993; Ronan & Cleary 2000). In the agricultural sector, performance benchmarks have been developed for a number of areas including wool quality, milk production and crop yield. Currently there are a range of ongoing benchmarking projects operating throughout Australia including TOPCROP, 8x5 Wool

Profit Program and the South West Victorian Farm Monitor Project (RIRDC 2000; Counsell 2004).

2.2.4 Overview of the benchmarking process

The process of benchmarking involves finding, adapting and implementing processes that enable superior performance of an enterprise (Williams 1997; RIRDC 2000; Tocker 2006) and can be simply defined as a measure of 'where you are compared to where you have been or where you could be'. Benchmarking provides an informative and accurate indication of where an enterprises performance sits in comparison to other similar enterprises, and/or between years, and identifies both the strengths and weaknesses of the enterprise. Some of the issues that can be addressed through rural benchmarking activities include; how an enterprise or farm is performing; how this overall performance might be improved; whether current management practices are suitable and how they may be improved; the return on assets and investments; and the potential risks or benefits associated with alternative management decisions (Newman & Chapman 2001; Wilson *et al.* 2004; Holmes *et al.* 2005).

Figure 2.4 illustrates the process of benchmarking and clearly shows the cyclical nature of benchmarking leading to continuous improvement (Cowper & Samuels 1997).

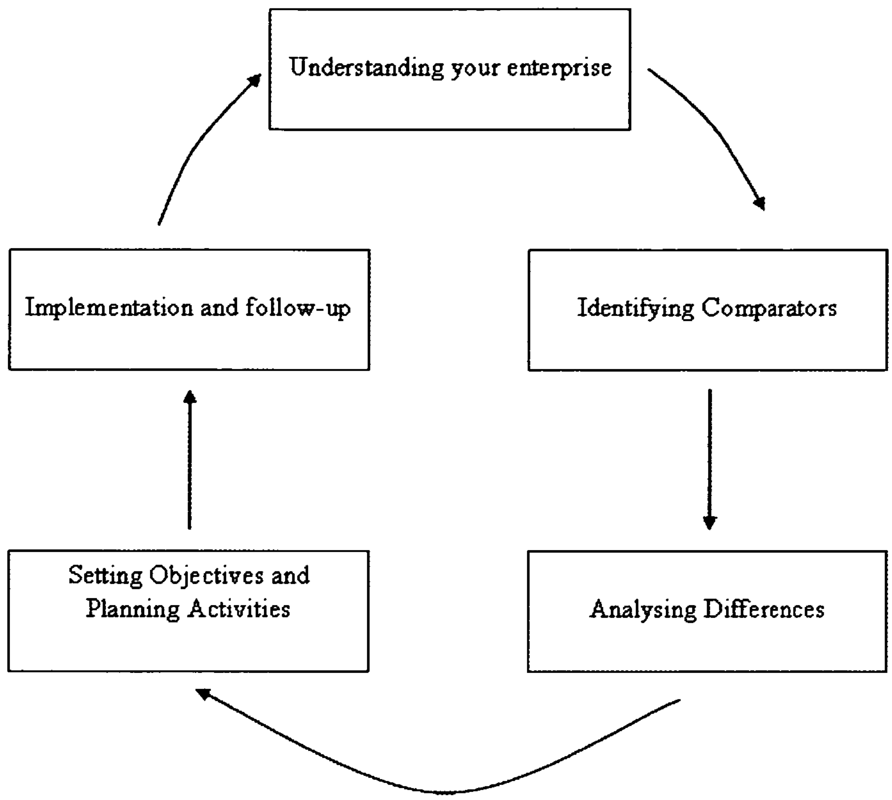

Figure 2.4 The benchmarking process for continuous improvement (from Cowper & Samuels 1997)

Any measurable attribute can be used in a benchmarking exercise and these can involve both numeric and process aspects. Numeric benchmarking involves the collection and comparison of numeric data on a specific outcome. Such data is useful to determine the size of differences in enterprise performance and measurable goals, but does not always provide information on exactly how these outcomes were achieved. Process benchmarking is used to identify the attributes that determine the performance outcomes of the enterprise (Le Sueur 1997). Performance benchmarking utilises both of these methods to identify the strengths and weaknesses of an enterprise and which management practices lead to superior performance.

The process of performance benchmarking can be simplified into three key stages: i) planning; ii) analysis; and iii) integration and action (Le Sueur 1997; Steudler & Kaufmann 2002). The three key stages are discussed below in more detail.

2.2.5 Planning - identifying comparators and key performance indicators

Benchmarking is a broad process that can be applied at a range of different levels. Provided there are appropriate units for comparison (whether they are theoretically achievable limits or other producer's data or data across years), any measurable aspect of any enterprise can be benchmarked. In financial benchmarking the most common comparisons are made between similar enterprise in particular regions (AusIndustry 1993; Le Sueur 1997; Clark & Timms 2001; Steudler & Kaufmann 2002). However, it is possible to make comparisons at enterprise, region, industry, state and national levels, and either within or between years.

Selection of which attributes are to be measured will depend largely on the type of enterprise to be benchmarked and of the importance of each attribute in determining the performance outcomes of that enterprise (AusIndustry 1993). Identification of what data to collect will generally focus on previously identified important attributes. Although collection of broader data can help to validate results and may provide insights into less obvious performance indicators and productivity drivers (Le Sueur 1997), unnecessary data collection can have a negative impact on the efficiency of the benchmarking activity.

The identification of KPIs is one of the most significant applications of financial benchmarking (Newman & Chapman 2001; Holmes *et al.* 2005). KPIs are underlying factors that determine the potential profitability of an enterprise. For example, in most enterprises, factors such as the COP per kg of product, dry sheep equivalents (DSE)/labour unit and income per DSE are important KPIs. The KPIs for different enterprises may reflect the intrinsic differences in management and production systems. Table 2.1 and Table 2.2 below list important KPIs identified by Newman and Chapman (2001) and Holmes *et al.* (2004). Newman and Chapman (2001) categorised the KPIs into 5 key groups (productivity, people, pecuniary, profitability and property) whereas Holmes *et al.* (2004) identified KPIs for specific enterprises such as beef breeding, cattle trading, wool, dual purpose sheep and sheep meat.

Table 2.1 Key performance indicators for beef production as identified by Newman and Chapman (2001)

Productivity	People	Pecuniary	Profitability	Property
Beef productivity (kg/Ha/100mm rainfall)	Training (days/FTE)	Finance ratio	Earnings before interest and tax ($/Ha)	Total DSE managed
Gross margin ($/Ha)	Gross product ($/FTE)	Expense ratio	Return on assets managed (profit as % assets)	DSE days/Ha/100mm rainfall
Cost of production ($/kg)				

kg-kilogram Ha-hectare FTE-full time equivalent

Table 2.2 Key performance indicators for different livestock industries identified by Holmes *et al.*(2004)

Beef breeding	**Cattle trading**	**Wool**	**Dual purpose sheep**	**Sheep meat**
Cost of production/kg beef	Price paid/kg beef produced	Cost of production/kg clean wool	Cost of production/kg lamb Dwt	Cost of production/kg lamb Dwt
Price received/kg beef	Price received/kg beef sold	Price received/kg clean wool	Price received/kg lamb Dwt	Price received/kg lamb Dwt
Gross $/head sold	Trading margin ($/head)	Prices as % of micron price indicator	Gross $/lamb sold	Average lamb price ($/head)
Kg beef/ha	Weight gain/head (lwt)	Kg clean wool/adult shorn	Lamb carcase kg/ewe	Kg lamb/ha (Dwt)
Kg beef/ha/100 mm rain	Enterprise size	Average adult fibre diameter (micron)	% of income from wool	Kg lamb/ha/100mm rain
Mid winter stocking rate (DSE/ha)		% income from wool	Cost production/kg clean wool	Weaning %
% potential stocking rate		Kg clean wool/ha	Price received/kg clean wool	Kg lamb/DSE (Dwt)
Kg beef/DSE		Kg clean wool/ha/100mm rain	Fibre diameter (micron)	Kg lamb/head sold (Dwt)
Kg beef/head sold		% DSE as wethers	Mid winter stocking rate (DSE/ha)	Mid winter stocking rate (DSE/ha)
DSE/labour unit		Mid winter stocking rate (DSE/ha)	% of potential stocking rate	% of potential stocking rate
Enterprise size (annual average DSE)		% of potential stocking rate	DSE/labour unit	DSE/labour unit
		DSE/labour unit	Enterprise size (annual average DSE)	Enterprise size (annual average DSE)
		Enterprise size (annual average DSE)		

Dwt-dressed weight lwt-liveweight kg-kilogram Ha-hectare DSE-dry sheep equivalent

Performance benchmarking allows the identification of the strengths and weaknesses of enterprises against specified criteria and over time. As a consequence, it is then possible to determine what management decisions have the greatest influence on productivity and profitability of the enterprise (Ronan & Cleary 2000).

2.2.6 Analysis and interpretation

The first step in the analysis stage of benchmarking involves the selection of suitable performance indicators to enable the discrimination of the magnitude of differences between actual and desired production levels. Accuracy of calculations is critical to the analysis and so care must be taken to eliminate errors (AusIndustry 1993; Le Sueur 1997; Steudler & Kaufmann 2002). Assuming that accurate and concise data are recorded, the next step is to examine and interpret these data and to establish procedures that allow the producer to identify and adopt processes that may increase productivity.

When analysing results from benchmarking activities it is important to understand the different methods of reporting and how these apply to different benchmarking activities. There are two methods of reporting: "read down" (RD) and "do not read down" (DNRD). Table 2.3 illustrates the different methods of reporting from a dairy benchmarking project (Ronan & Cleary 2000). In Column A, non-identical farm samples are used and so the DNRD method must be applied. Individual parameter results cannot be directly linked or compared as they are from non-identical farms. This method of reporting is most effective when focussing on individual problem areas and single indicators such as stocking rate or cost of production.

When wanting to link or compare across multiple parameters the RD reporting method can be used. This is illustrated by the data shown in Column B. In this situation the farm sample for each benchmark parameter is identical and single parameters can be judged against a background of performance in related parameters. For example, using the RD method in Column B, it is possible to directly compare different parameters such as stocking rate and pasture costs or milk/cow and dairy profit per effective land area. This form of reporting can provide valuable group or industry insights due to the capacity to compare across farms.

Table 2.3 Examples of the Do Not Read Down (DNRD) and Read Down (RD) methods of reporting benchmarks (Ronan & Cleary 2000)

	Column A - DNRD		Column B - RD	
'Benchmark' Parameter	'Best' Result	Farm ID No	'Best' Result	Farm ID No
Stocking Rate (Cows / EDHa)	3.74	37	2.08	2
Milk / Cow (kgMS)	10,730	22	6,022	2
Milk / EDHa (kgMS)	21,033	37	12,555	2
Cows / Labour Unit	74	16	67	2
Milk Unit Cost of Production (c/l)	29.8	11	35.8	2
Dairy Profit / EDHa)	$1,508	2	$1,508	2

EDHa = Effective Dairy Hectare (accounts for different pasture productivity values), kgMS = kilograms of milk solids.

2.2.7 Integration and action

Benchmarking can be undertaken for an entire business through to individual components of an enterprise. The strength of the analysis comes from showing how all of the performance measures are linked to productivity, costs, profit and return on investment (Ronan & Cleary 2000). The process of benchmarking may not be complete until the information is used to inform a plan of action. A benchmarking activity can be regarded as successful if, for example, it facilitates change for the better and results in sustainable productivity and profitability (Ronan & Cleary 2000).

The continuous improvement philosophy is a process that enables producers to regularly and frequently focus their thinking and action in order to achieve a positive impact on their performance through improved current practices, processes, systems, products and/or services. Action and implementation of strategies aimed at the identified benchmarks at the farm level is essential if the benchmarking process is to effectively create change and improvement. Continuous monitoring of performance indicators can enable producers to recognise if and when production targets have been reached (Le Sueur 1997; Clark & Timms 2001). The introduction of benchmarking activities into established farmer discussion groups can help support continuous farm improvement at the regional and industry level (RIRDC 2000).

2.2.8 Issues and limitations of benchmarking

In agriculture many decisions that are made have a certain element of risk associated with them. The implementation of new practices to improve enterprise performance is not a simple process and the financial implications and viability of any new practices should be considered thoroughly. The erroneous assumption that practices which work in one system will work in another could lead to a decline in enterprise performance and so careful consideration, trial and fine tuning are all necessary to ensure successful application of benchmarking information (Le Sueur 1997; Steudler & Kaufmann 2002). When determining any possible course of action from benchmarking it is important to also consider these risk factors and the impact that they may have (Purdy *et al.* 1997; Fleming *et al.* 2006).

Malcolm and Ferris (1999) argued that benchmarking can be an imprecise process relying too heavily on unfounded information that is not sufficiently supported by evidence The result of any benchmarking process can only be as good as the information processed, so it is vital that the information used is of high quality, namely relevant and accurate. Failure to use accurate, standardised data will result in increased frequency of errors and inaccuracies, potentially resulting in invalid comparisons and flawed recommendations (Le Sueur 1997).

Despite accurate information collection and analysis, due to the associated time and financial costs in data collection, there may be unmeasured variables that significantly influence the productivity of an enterprise. These include social factors such as the farm family structure, and personal and family business attitudes to risk. These social factors will often result in divergent judgements, decisions and actions being taken about how best to improve the productivity of an enterprise (Malcolm & Ferris 1999; Counsell 2004). These factors and their potential influence on management should be recognised and allowed for in the benchmarking exercise.

One common output from benchmarking programs are ranking systems that list enterprises based on the results obtained. Such tables have been criticised for putting too strong a focus on targets rather than identifying underlying weaknesses in farm production and suitable opportunities for improvement. Although benchmarking can accurately identify those processes that create greater productivity, it may not provide a single solution that can be applied in every instance. It is important when interpreting results from benchmarking activities to ensure that any information produced is used prudently rather than as a strict guideline. Many enterprises have unique characteristics, so what works in one situation is not necessarily guaranteed to produce the same result in another situation. Moreover, when results from benchmarking are released the information should be clear, succinct and precise to avoid misinterpretation and inappropriate application (Cowper & Samuels 1997; Rohloff 1999; Greggery 2002).

Fleming *et al.* (2006) raised a concern that benchmarking could be a new guise for the discredited comparative analysis technique, but acknowledged that benchmarking can be a valuable tool to measure farm performance if properly employed. Proponents of rural benchmarking programs have acknowledged the potential limitations associated with benchmarking and provided options to address these issues, as outlined previously in this section. By adopting standardised terms and methods for benchmarking, as well as remembering that benchmarking is a tool to identify strengths and weaknesses rather than a strict guide or as a substitute for good farm management, the most value can be gained from the activity and the risks of inappropriate application minimised (Malcolm & Ferris 1999; Ronan & Cleary 2000; Fleming *et al.* 2006).

2.3 Geographic Information Systems and Spatial Modelling in Agriculture

2.3.1 Introduction

A Geographical Information System (GIS) constitutes an integrated, computer-based system for analysing, modelling, mapping and displaying spatial information (Delaney 1999). Burrough (1986) defined GIS as "a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes". GIS has many components including both hardware and software that enable the input, storage, management, retrieval, manipulation, analysis and output of complex data that are spatially-referenced.

GIS has existed since the 1960s and the use of these systems has grown dramatically since the 1990s, as computer technology has become more advanced and affordable, software has become more user-friendly, and spatial data have become more widely available in digital format (Green *et al.* 1994). Many industry, government, academic and community organisations now use GIS on a daily basis to service their needs, in areas such as land and resource management, forestry management, environmental impact assessment, urban planning and civil engineering (Laurini & Thompson 1995).

2.3.2 GIS methods

Real world objects can be represented in 3 dimensions in a GIS and temporal changes can be modelled or simulated. Objects can be divided into two classes: discrete objects (such as buildings or roads) and continuous fields (such as rainfall or elevation) (Delaney 1999). Attribute and spatial information is integrated into the GIS through data layers that are not dissimilar to the more traditional methods of forming data into layers, such as lithographs. Data layers may have a thematic basis and represent features such as topography, land cover, land use, roads and human settlements (Laurini & Thompson 1995).

Data layers can be stored as vector or raster data. Vector data are stored in the form of points, lines (or arcs) and polygons to represent various features, objects and phenomena that occur in the real world. For example, a vegetation community may be represented by a polygon or a road may be shown as a line. To ensure spatial integrity is maintained in vector data, topology rules are applied (e.g. polygons must not overlap, all roads must connect with nodes at intersections) (Delaney 1999). Raster data are used for the storage of information and can include discrete values such as land use, or continuous values such as rainfall. The raster data layer is comprised of rows and columns of pixels or cells (Delaney 1999).

Data used in GIS can be acquired and derived from a range of sources. Existing hard copy or analogue data (e.g. maps or images) can be digitised or scanned to produce digital data. Modern surveying equipment, Global Positioning Systems (GPS), aerial photography and satellite remote sensing now capture raw data in digital form to accommodate ready use within a GIS (Delaney 1999).

2.3.3 The role of GIS in agriculture

GIS in Australia has played an important and expanding role in land management and natural resource management in the past decade (CRCSI 2007). The advantages provided by GIS for land management (Delaney 1999; ACIL Tasman 2008) include the ability of the technology to:

- assemble and maintain large amounts of geo-referenced biophysical data;
- act as an integrating technology to allow for the combination, manipulation and cross-analysis of otherwise disparate data; and,
- maximise the utility and application of data and derived information across the widest range of decision making processes.

GIS technology is of significant benefit to agriculture, and is estimated to have increased broad-acre agricultural productivity by 10% (ACIL Tasman 2008). GIS technology can play a significant role in ensuring that agricultural land resources are suitably matched to management practices based on their capability (Smith & McNeill 2001). When land use and intrinsic capability are mismatched both the land and water resources can deteriorate and productivity can be compromised. In many parts of Australia there is widespread land degradation often resulting from unsuitable land use (NLWRA 2001). Through the use of GIS technologies it is possible to identify and map land capability and, thus, advise on the most appropriate land use and management practices (NLWRA 2001). Other applications of GIS in agriculture include climate prediction, modelling water use and availability, and modelling and mapping pasture growth (Laurini & Thompson 1995).

In agriculture there is an ongoing need to become increasingly efficient. Technologies such as GIS provide a valuable tool to aid in increasing farm efficiency (Murray *et al.* 2007). For example, it is widely accepted that climate (particularly rainfall) combined with soil characteristics, fertiliser history and topography have a strong influence over the production potential and botanical composition of pastures. Through the use of GIS it is possible to map these factors to inform the best use of available resources for sustainable pasture production (Murray *et al.* 2007).

Another example of the application of GIS is the role it plays in 'precision agriculture' - a technology-based method of providing detailed information about geographic location, and spatial and temporal variability in soils and crops (Smith *et al.* 1995; Whelan 2007). This information can be used by producers and advisers to improve cropping decisions, crop agronomy and the efficiency of farming operations (Woodrow 2001; Lythgoe *et al.* 2004; Warren & Metternicht 2005). Precision agriculture combines a wide range of data sources based on a common geographic location. GIS can be used to map crop yield to check the performance of different crop varieties or the impact of a pesticide (Woodrow 2001; Fetch *et al.* 2004; Whelan 2007). Crop yield may be monitored directly during harvest with geographic location provided from a GPS and compared to biomass estimates made from satellite images or to soils data from an electromagnetic induction survey (Cook *et al.* 1996). The relationship between crop yield and paddock conditions may be mapped and visualised using GIS. This agricultural technique is underpinned by spatial data, much of which reflects spatial variability due to past management and crop performance, such as high fertility levels remaining where crop yield has been poor.

In the USA a well established agricultural analysis and comparison tool known as AgriFACTs has been developed (Aiken *et al.* 2001). AgriFACTs enables producers to access spatial data and information on biophysical factors such as precipitation and soil water-holding capacity. AgriFACTs can also be used in conjunction with GIS software to create maps and produce farm reports (Aiken *et al.* 2001).

GIS has a role to play in the management of extensive livestock industries. For example, one important management decision involves setting stocking rates at sustainable levels, based on the limitations of the climate, soil and pasture resources. Choice of stocking rate affects the efficiency with which key resources such as pasture and labour are utilised (Alcock 2006). Spatial modelling can be used to identify potential pasture production, land capability and risk factors, all of which will assist in selecting suitable stocking rates at a whole farm as well as paddock level.

In Australia the use of GIS based technology has been demonstrated through the Pastures From Space program which uses remote sensing to estimate pasture feed on offer (Donald *et al.* 2004; Edirisinghe *et al.* 2004; Mata *et al.* 2004). Use of Pastures From Space technology has enabled producers to increase their productivity and profitability through better pasture utilisation, stocking rates, grazing strategies and fertiliser application (Anderton *et al.* 2004; Donald *et al.* 2004; Gherardi *et al.* 2006).

2.3.4 Combining GIS and simulation modelling

GIS technologies can be used to view information from previous years or seasons and to build forecasts of production output based on this information. In addition, this technology can be linked to predictive models to estimate and evaluate the potential impact of different agricultural management decisions (Hill *et al.* 1999). Numerous studies have shown the potential for incorporation of GIS techniques into established predictive models and decision support tools (Hill 1996; Hill *et al.* 1996; Hill *et al.* 2000; Zhang *et al.* 2004; Murray *et al.* 2007). This integration enables producers to see how changes in management practices may affect their productivity and profitability as well as put the potential outcomes of various management options into context (Hill *et al.* 1999; Hill *et al.* 2000; Alcock 2006). The use of simulation models enables the examination of complex management option changes at paddock, farm and catchment scales. Hill *et al.* (1999), for example, identified the following three points as beneficial potential applications for a time series of maps:

- Identification of chronically poorly productive areas that require changes in management, inputs or land use
- Estimation of the impact that changes in inputs or re-sowing of pastures may have in relation to pasture production, animal production and economic benefits
- Comparative assessment of paddock performance as the basis for decisions on stocking and crop rotations.

2.4 Integration of Spatial and Financial Data

In review, farm financial benchmarking can provide a comprehensive basis for producers to quantitatively evaluate the financial performance of their enterprise. In order to gain a more complete understanding of the underlying factors influencing production and profitability, it is also necessary to examine the biophysical aspects of an enterprise. Information relating to the biophysical characteristics of an enterprise can be obtained using GIS techniques and modern computer-based spatial information science tools. This section considers some of the advantages and limitations of current approaches to integrating spatial and financial data for analysing business performance in agriculture.

There is great potential for further application of GIS technologies within the agricultural industry. Agriculture is both spatially extensive and includes environmental and socio-economic networks, so improvements in approaches integrating GIS spatial data and farm economics may have significant benefits for the sector (Moxey 1996). Integration of spatial characteristics transforms inadequately represented characteristics into a key element of empirical economic investigations of farm performance (Moxey 1996; Bateman *et al.* 1999; Bateman *et al.* 2002). Integration of spatial data from GIS with economic data creates an opportunity for much greater realism, comprehensiveness and relevance in modelling agricultural production systems (Bateman *et al.* 1999).

2.4.1 Matching environment characteristics and economics in Wales

Through the integration of farm environmental characteristics with economic data it is possible to improve farm productivity and profitability. The successful integration of site-specific biophysical factors with farm-level data to predict input usage and subsequent farm profit was demonstrated by Bateman *et al.* (1999) in their study into dairy and sheep farming in Wales. The authors used GIS to integrate and relate a variety of spatially-referenced data, which were relevant to individual farm costs and revenue, with data regarding the biophysical characteristics of each farm. Through development of GIS-based modelling methods, these researchers were able to analyse and model the dairy and sheep industries in Wales at a highly disaggregated level. They allocated properties into groups depending on the proportion of total annual revenue from each enterprise, with most farms categorised as either Dairy or Sheep farms.

Bateman *et al.* (1999) focussed on predicting production inputs and farm profit by combining farm level data and site-specific biophysical factors. The economic data used were obtained from the Farm Business Survey of Wales and biophysical data were sourced from the LandIS database. The location of each farmhouse was used to geographically reference the farm. A two stage procedure for analysis modelling was employed. The first stage determined the income values based on the range and intensity of inputs utilised, and in the second modelling stage, the inputs employed were dependent on the prevailing biophysical characteristics and possible modifications of those characteristics. Cross-section regression analysis was used to estimate the parameters of the relationships of both stages within the dairy and sheep sector. The predictions from these models were then extrapolated with GIS to yield agricultural value maps.

The matching of farm economic and environmental variables in this way was considered by the authors as considerably more meaningful then previous research that had relied on agricultural census data aggregated into parishes. The maps produced from this research were compatible with maps of alternative land use given in the literature and with approaches to policy formulation currently under development by a range of agencies in Wales (Bateman *et al.* 1999).

The benefits of applying GIS to economic indicators was also demonstrated by Bateman *et al.* (2002) in their study into environmental and resource economics in Wales. The study highlighted how GIS can considerably enhance the incorporation of spatial issues within applied environmental and resource economics. Examples of such enhancement include the ability to quantify and present issues of interest to economists and to identify the presence of features, such as land use change or species diversity, at a specific location. The methodology employed in these studies allowed for estimation of both the market and shadow values (farm gate income after adjustments for subsidies and levies) of current agricultural output for a large study area. These studies also permitted explicit incorporation of biophysical data within the economic modelling of output values.

2.4.2 Analysis of policy decisions

The use of decision support tools and techniques can also be used to analyse the outcomes of management and policy decisions by government or industry, and to gain a greater understanding of the relationships between different land uses. The potential to incorporate economic and biophysical data to develop decision support tools has been demonstrated in the UK through the National Environmental Resource Council-Economic and Social Resource Council Land Use Programme (NELUP) (O'Callaghan 1995; Oglethorpe & O'Callaghan 1995; Bateman *et al.* 1999). The NELUP decision support system enabled an integration of the land, air and water resources databases to provide information for planning new land uses. NELUP was designed predominantly for use by Government and local organisations whose interests are at a regional level, rather than at an individual farm level (O'Callaghan 1995).

Using the modelling capability of tools such as NELUP allows policy and management options to be analysed. The outcomes of analysis can then be discussed widely to determine the most suitable management choice. Although the NELUP tool has been shown to be a useful industry wide tool in the UK it is limited in its application at an individual property level (O'Callaghan 1995). New tools and approaches are required to support more sophisticated integration and analyses of economic, social and biophysical data at the farm scale.

2.5 Conclusions

Techniques and tools, such as farm financial benchmarking and GIS, allow beef producers and industry policy makers to gain a greater understanding of the drivers of productivity and profitability, and therefore can be used to help alleviate or capitalise on some of the challenges currently being encountered in the beef industry.

Both GIS and benchmarking have been used for a range of purposes throughout the world and the ability of both of these methods to produce concise, relevant information has been demonstrated. This suggests that the best approach to this study was by integrating GIS and benchmarking. The use of these tools both separately and in an integrated way provides an opportunity to analyse and assist the beef industry in Tasmania. The literature and techniques reviewed in this Chapter provide the context for, and inform the analyses of the beef industry in Tasmania presented in Chapters 3-5, below.

3. 'Setting the Scene': a biophysical description of the beef industry in Tasmania and identification of areas with potential to support beef production

3.1 Introduction

Beef production in Australia occurs across a large and diverse geographic area including the semi-arid regions of the Northern Territory to the cool temperate regions of Tasmania. As a result, a wide range of environmental conditions are experienced by the nation's beef industry (McIvor 2005; ANRA 2007). These varied conditions result in different challenges to the industry and often require different management approaches to improve farm production outcomes and best practice in terms of environmental management ('Grasslands Perspectives' 2005).

An understanding of the potential effects of environmental variation on beef enterprises is important in order to support the sustainability of the industry, and for adapting to challenges such as climate change (Ash *et al.* 2008). Farm and animal production may be strongly influenced by the quantity and quality of the natural resources available for farming and the quality of resource management. Environmental factors known to affect farm productivity include climate variability, local topography and access, local hydrology and drainage, vegetation and soil quality (Pearson & Ison 1987; Ash *et al.* 2008).

GIS technology and techniques provide a means to model spatially-defined variables such as climate, terrain, land cover, soil type and fertility (Delaney 1999). These techniques can be used to assess the range of environmental conditions experienced by different agricultural industries across regions, such as Tasmania, and to evaluate the relative importance of these environmental variables to agricultural production (Woodrow 2001). Indeed, environmental factors such as these have been used to describe the suitability of broad regions for agricultural production in Australia (e.g. Williams 2002; Australian Government 2009; AustralianGovernment 2009), and globally (Millennium Ecosystem Assessment 2005).

Although the beef industry in Tasmania is generally confined to the established agricultural regions in the north-west, north-east, south and south-east of the State, these regions span a range of environmental gradients that may influence production (IRIS 2008; DPIW 2009). To improve understanding of the range of environments supporting beef production in Tasmania this Chapter outlines the use of GIS technology and spatial modelling tools to describe these gradients. Moreover, this information was used to identify other areas of Tasmania with the potential to support beef production. Specifically, the aims of Chapter 3 were to:

- use selected biophysical attributes to describe the landscapes currently supporting beef enterprises in Tasmania
- use the biophysical description of the beef industry in Tasmania to identify land with the potential to support beef farming.

3.2 Methods

A range of biophysical or environmental variables were examined in this study (Table 3.1). Data were accessed from institutional sources including; Cradle Coast NRM based in Burnie; Tasmanian Department of Primary Industries Parks Water and Environment (DPIPWE); Australian Government Department of Environment, Heritage, Water and the Arts (DEWHA); Land and Water Australia; Greening Australia (Tasmania); Private Forests Tasmania; Forestry Tasmania and the University of Tasmania (UTAS). Data sourced from DPIPWE, including that from the Land Information System (LIST), were obtained using a data share service agreement that UTAS holds with that government portfolio. All data sets were based on data sourced during the period 2006 to 2009 and, to the best of my knowledge, were the most up-to-date available.

Table 3.1 Spatial databases available to characterise the biophysical attributes of beef enterprises in Tasmania.

Environmental themes	Spatial layers	Information	Scale	Data Source
Topography	Digital Elevation Model (DEM)	Terrain variation – slope, aspect, surface curvature, drainage (upslope area)	1:25,000	LIST – DPIPWE
Climate		Temperature, Precipitation, Soil water balance	1:25,000	LIST – DPIPWE
Land	Land	Land cover, land use, threats	1:100,000	LIST – DPIPWE, LWA
	Soils	Soil types	1:100,000	DPIPWE
	Geo-conservation	Distribution, status, threatening processes	1:100,000	DPIPWE
Water	Water	Quality & quantity, access, dams	1:50,000	WaterWatch, LIST – DPIPWE & other sources
	Riparian vegetation	Extent, status	1:50,000	TASVEG, GA, LWA, LIST – DPIPWE
	Plantations – softwood & hardwood	Extent, expansion	1:50,000	F/T, PFT, LIST – DPIPWE

Key to acronyms: F/T = Forestry Tasmania, GA = Greening Australia (Tasmania), LWA = Land & Water Australia, LIST = Land Information System Tasmania, PFT = Private Forests Tasmania, TASVEG = Tasmanian Vegetation cover (Version 1.3).

Climate surfaces and an index of mean annual water balance for Tasmania were derived at a scale of 1:25,000 using the software ANUCLIM, ESOCLIM and BIOCLIM (CRES 2009; Norton 2009a) and the 1:25,000 DEM sourced from DPIPWE.

The State government property identification numbers (PIDs) were used to help identify the land area supporting beef production across the State. The spatial data organisation and analyses were undertaken using GIS technology based within the NRM group of TIAR at the Cradle Coast Campus of the UTAS at Burnie, and at RMIT University in

Melbourne, Victoria. The database was created using a Dell Precision 690 desktop computer, a HP 5500ps 42" Plotter and software including ESRI ArcInfo and ArcView Version 9.2 (ESRI, Redlands, CA, USA, www.esri.com, accessed December 2009), Business Objects Crystal Reports XI (SAP, Walldorf, Germany, www.sap.com/Australia/index.epx, accessed December 2009), Microsoft Office (versions 2003 and 2007 Microsoft Corporation www.microsoft.com/en/au/default.aspx, accessed December 2009), ANUCLIM, ESOCLIM and BIOCLIM 2008, (Australian National University, Canberra, ACT, AUS, http://fennerschool.anu.edu.au, accessed December 2009).

Spatial data for the area identified as supporting beef production were compiled to describe the natural resource features of the industry across the State. The range in biophysical variables was estimated for Tasmania as a whole, and separately for mainland Tasmania, King Island, and Flinders Island and compared to those estimated for the Tasmanian industry overall and the lands supporting the industry on the main island, King Island and Flinders Island. The zonal statistics function of ArcGIS was used to determine the minimum, maximum and mean values for rainfall, temperature, water balance, and slope. Land use data and soil type data were described using the Australian Land Use and Management (ALUM) classification (BRS 2005) and the Australian Soil Classification (ASC) (Isbell 1996), respectively. Polygons for land use and soil type were clipped to match the area outlined for beef production. Python scripts (written by G.Dickins, RMIT) were used to extract values for soil types and land use. The extracted values produced a list of all the soil types and land use classes present and the area covered by each soil type and land use class.

Soil types were grouped as those with relatively high soil fertility and those with relatively low soil fertility (Cotching 2009) (Table 3.2) As sapric organosol soils are highly variable and can be either relatively high or relatively low fertility, these soils were not included in these groups. The extent of these soil types on the beef producing area was very limited (1.14% of total area), and was not considered to significantly influence the subsequent analysis. Land use classes were grouped into: Irrigation, Improved Pasture, Unimproved Pasture, Forest and Plantations, and 'Other' categories (Table 3.3), unless otherwise stated in the text below.

Table 3.2 Grouping of soil type classifications based on relative fertility.

Relatively High Fertility Soil Types	Relatively Low Fertility Soil Types
Black Dermosol	Aeric Podosol
Black Vertosol	Aquic Podosol
Brown Dermosol	Arenic Rudosol
Brown Ferrosol	Brown Chromosol
Brown Kandosol	Brown Kurosol
Brown Vertosol	Brown Sodosol
Grey Dermosol	Brown-orthic Tenosol
Grey Kandosol	Chernic Tenosol
Grey Vertosol	Clastic Rudosol
Oxyaquic Hydrosol	Grey Kurosol
Red Dermosol	Leptic Rudosol
Red Ferrosol	Leptic Tenosol
Red Kandosol	Lithocalcic Calcarosol
Redoxic Hydrosol	Orthic Tenosol
Salic Hydrosol	Red Kurosol
Yellow Dermosol	Semiaquic Podosol
	Shelly Rudosol
	Yellow Chromosol
	Yellow Kurosol
	Yellow-orthic Tenosol

Table 3.3 Grouping of Land Use Classes.

Name	Land Use Classes*
Irrigation	4.2.0, 4.3.0
Improved Pasture	3.2.0
Unimproved Pasture	2.1.0
Forests and Plantations	3.1.0, 1.1.7, 2.2.0, 1.3.3, 1.1.5, 1.1.3
Other	All other land classes not previously classified

* Australian Land Use and Management (ALUM) classifications (BRS 2005)

Land with the potential to support beef production was identified using a filter comprised of two climate variables (mean annual temperature of 6.5-13^{O}C and mean annual rainfall of 496-2146mm), five soil types (brown dermosol, brown chromosol, brown kurosol, red ferosol, classic rudosol) and one slope class (<15 degrees). The range in mean annual temperature and mean annual rainfall was consistent with that identified for all beef properties on the Tasmanian mainland. The soil types were selected because they were the dominant (by area) on beef farms in Tasmania (see below). Land with shallow topography was chosen for analysis since this was considered the most suitable for beef production. For illustration, private land with the potential to support beef production based on these criteria, and which is currently used for other purposes, was mapped for the Tasmanian mainland, only

3.3 Results

3.3.1 Biophysical features of beef farms in Tasmania

Beef enterprises in Tasmania are geographically widespread, extending from the North West to the North East (including King and Flinders Islands) and southwards along the East Coast and Midlands (Figure 3.1).

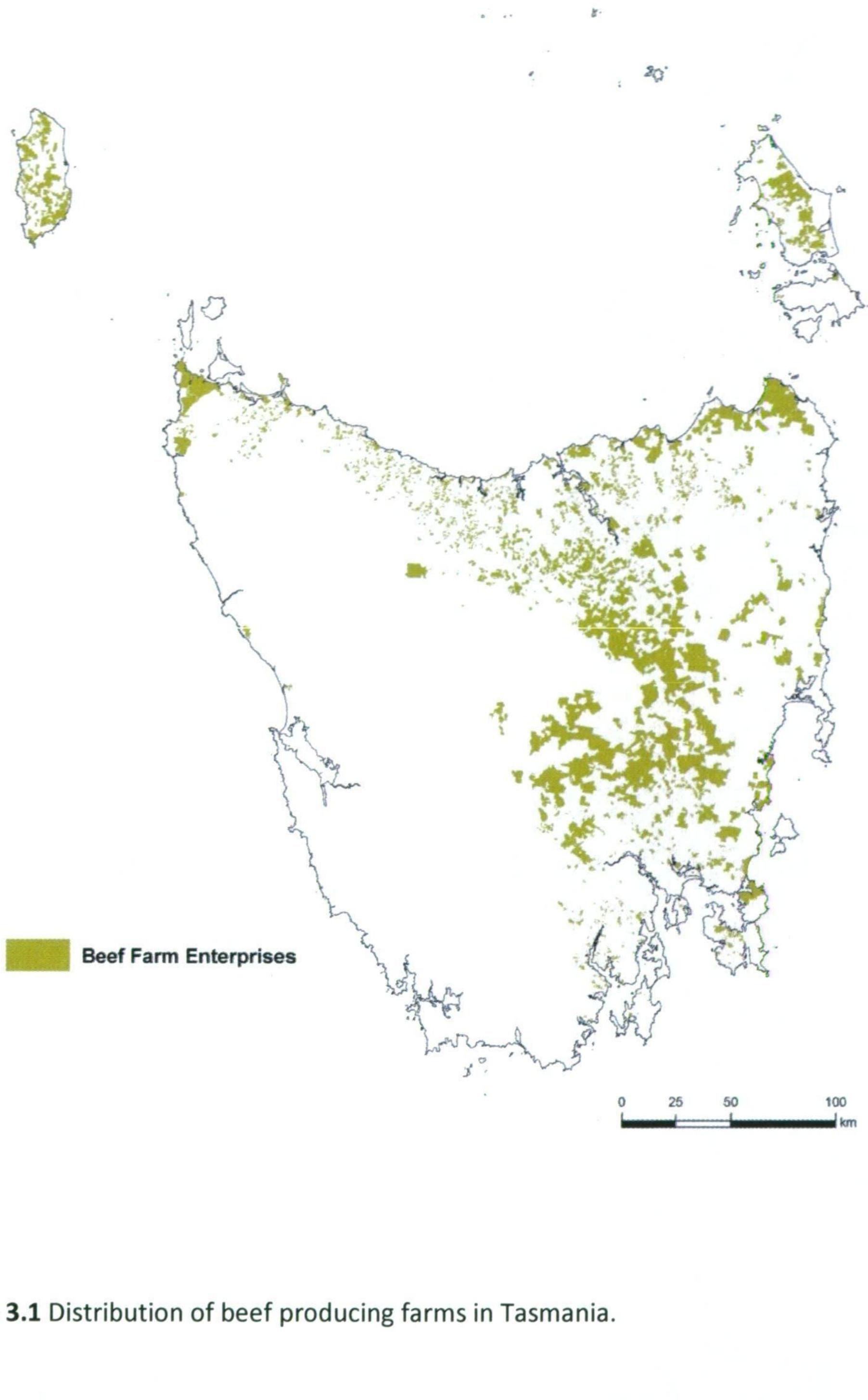

Figure 3.1 Distribution of beef producing farms in Tasmania.

The beef farms on the main island of Tasmania had a slightly higher mean temperature than the State-wide average. On King and Flinders Islands, the mean temperature was almost equal (0.1^{O}C and 0.2^{O}C difference, respectively) for farms and the entire island. The temperature range for the main island and Flinders Island was narrower for the beef farms than that estimated for the entire island. On King Island the temperature range estimated to be experienced by the beef farms was the same as that estimated for the entire island (Figure 3.2 and Figure 3.3).

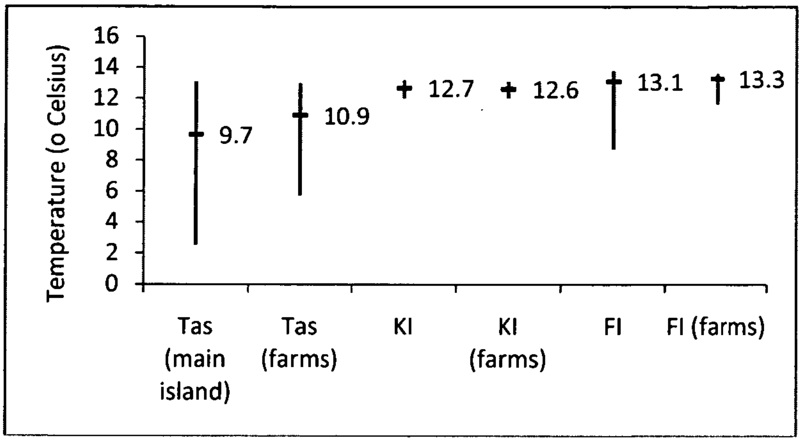

Figure 3.2 Temperature range for the State and beef producing areas. Mean values are indicated as bars on lines showing maximum and minimum values. King Island (KI) and Flinders Island (FI) were analysed separately to the main island. All values calculated are based on long term annual averages.

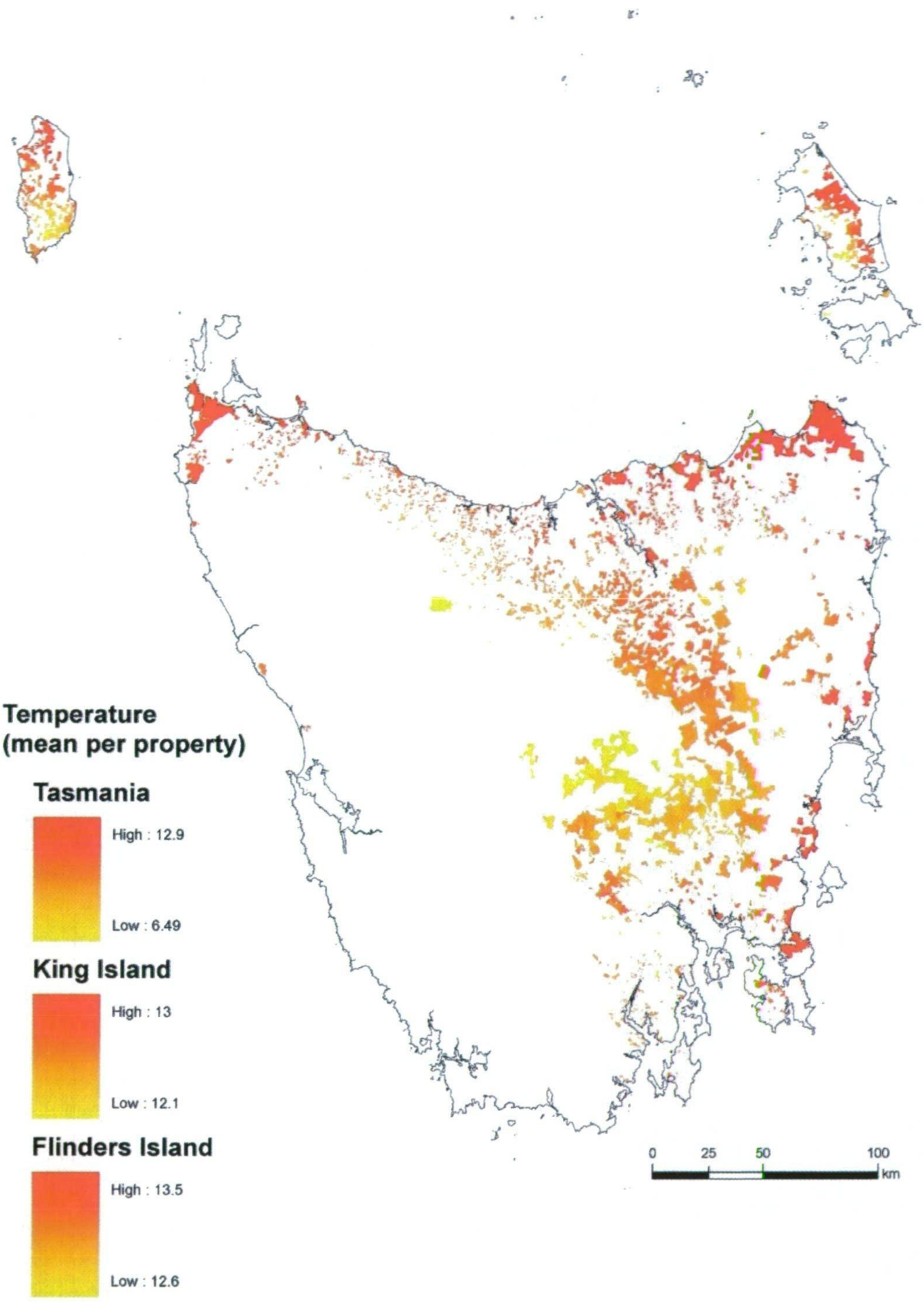

Figure 3.3 Range in mean annual temperature (^{O}C) of the area used for beef production in Tasmania.

The mean annual rainfall for farms on the main island of Tasmania was lower than that estimated for the State as a whole. There was a relatively small difference in mean rainfall values between the farms and the entire area of King and Flinders Islands. The farms on Flinders Island were estimated to experience a smaller rainfall range than that estimated for the main island (Figure 3.4 and Figure 3.5).

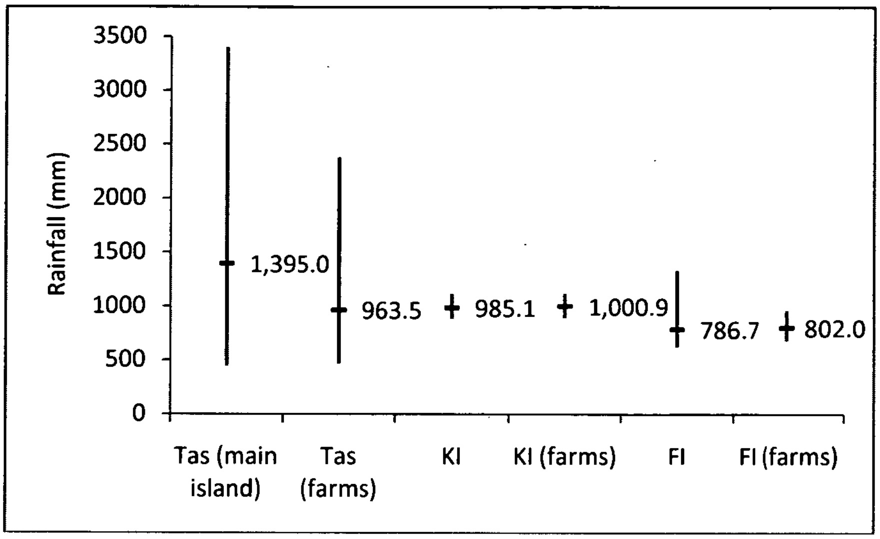

Figure 3.4 Rainfall range for the State and for beef producing areas. Average values are indicated on the maximum and minimum lines. King Island and Flinders Island were analysed separately to the main island. All values are calculated as long term annual averages.

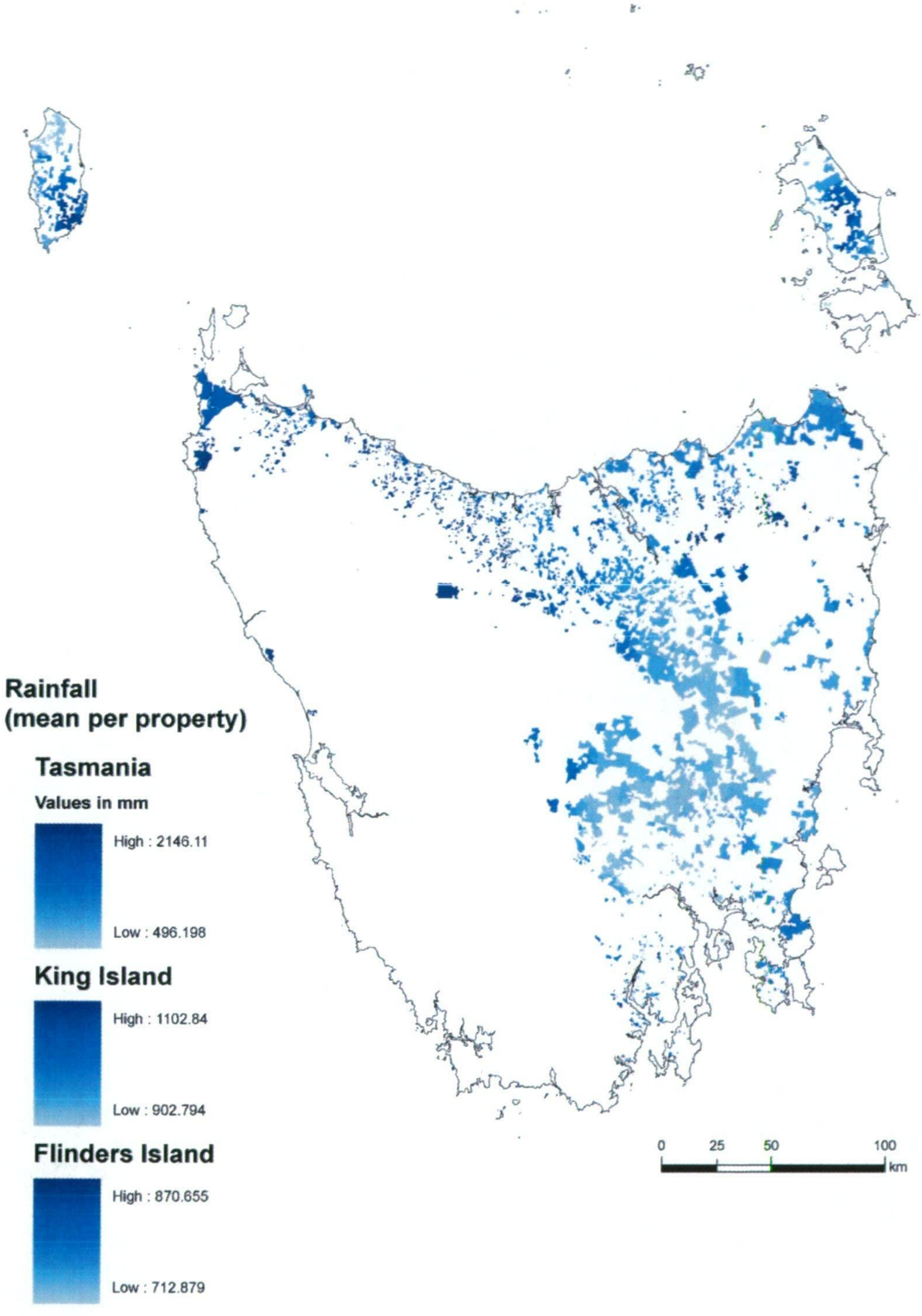

Figure 3.5 Range in mean annual rainfall (mm) for the area used for beef production in Tasmania.

The largest variation in an index of mean water balance between the farming areas and their corresponding total landscape was estimated to be on the main island of Tasmania where the difference was 0.08. There was a noticeable difference in the range of mean water balance estimated to be experienced by the beef farms compared to that estimated for the total area of Flinders Island (Figure 3.6 and Figure 3.7).

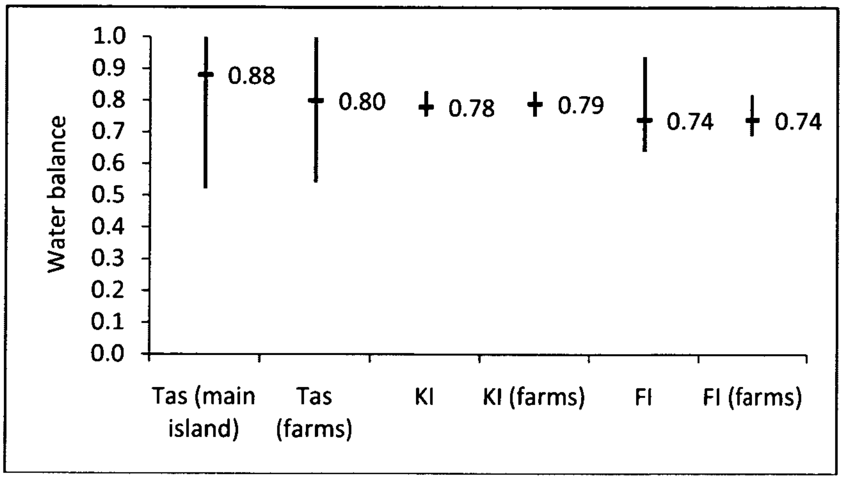

Figure 3.6 Relative index of water balance range for the State and for beef producing areas. Average values are indicated on the maximum and minimum lines. King Island and Flinders Island were analysed separately to the main island. All values are calculated as long term annual averages.

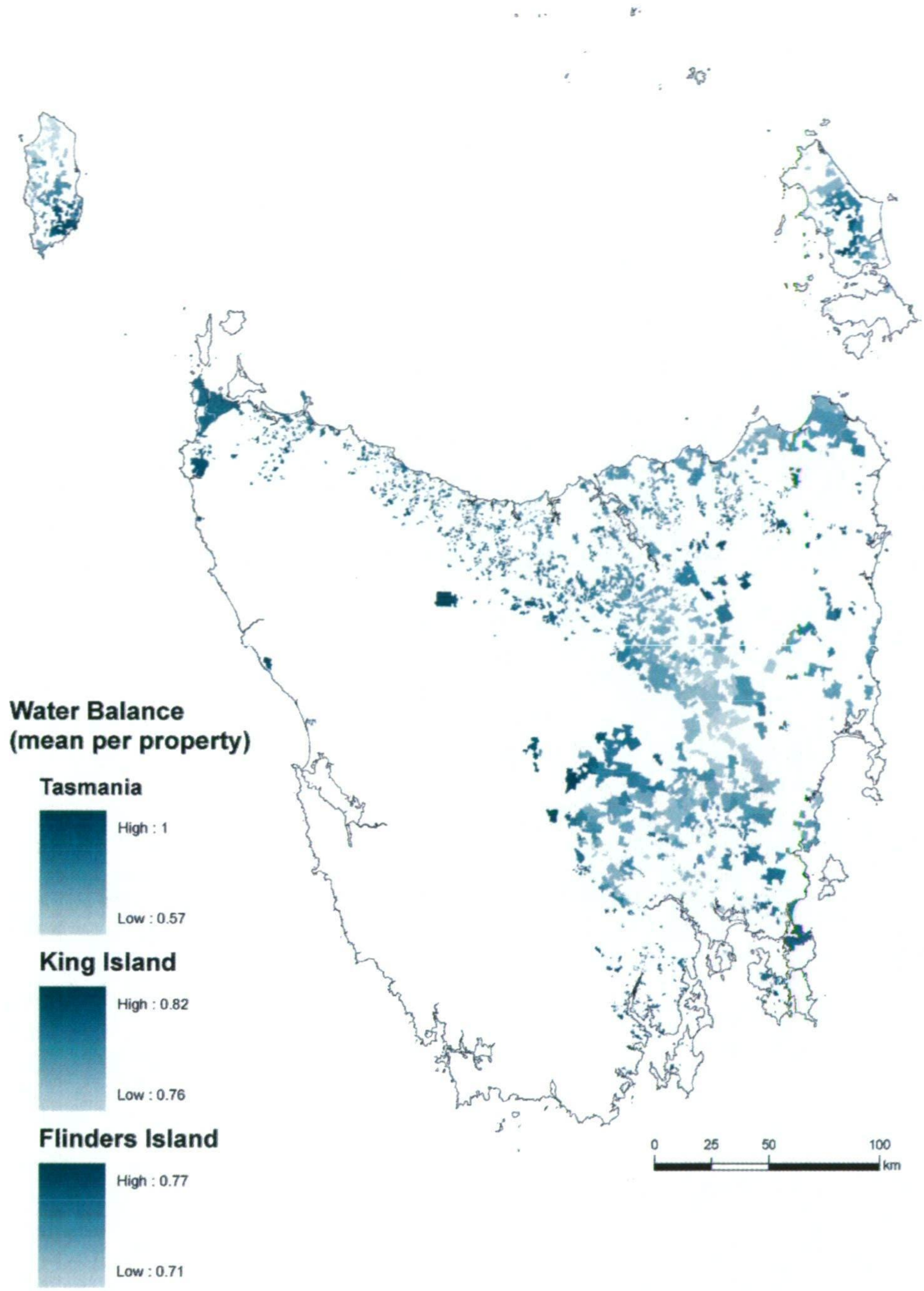

Figure 3.7 Range in a relative index of water balance (0-1) for areas supporting beef production in Tasmania.

The analysis of slope indicates that beef farms were generally located on flatter areas with the mean and the maximum slope being lower for these farms than that estimated for the State as a whole (Figure 3.8 and Figure 3.9).

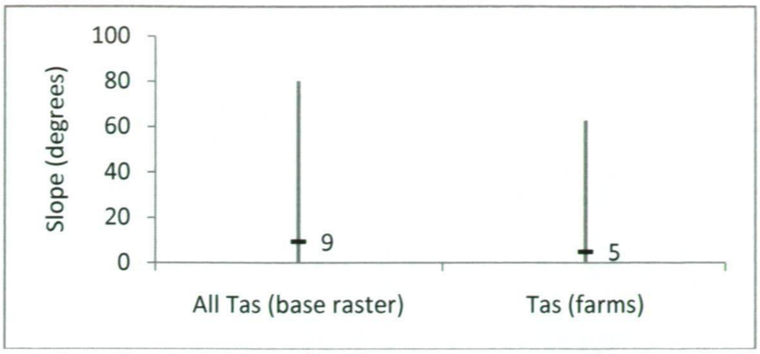

Figure 3.8 Range in estimated slope of landscapes supporting beef production in Tasmania. Average values are indicated on the maximum and minimum lines.

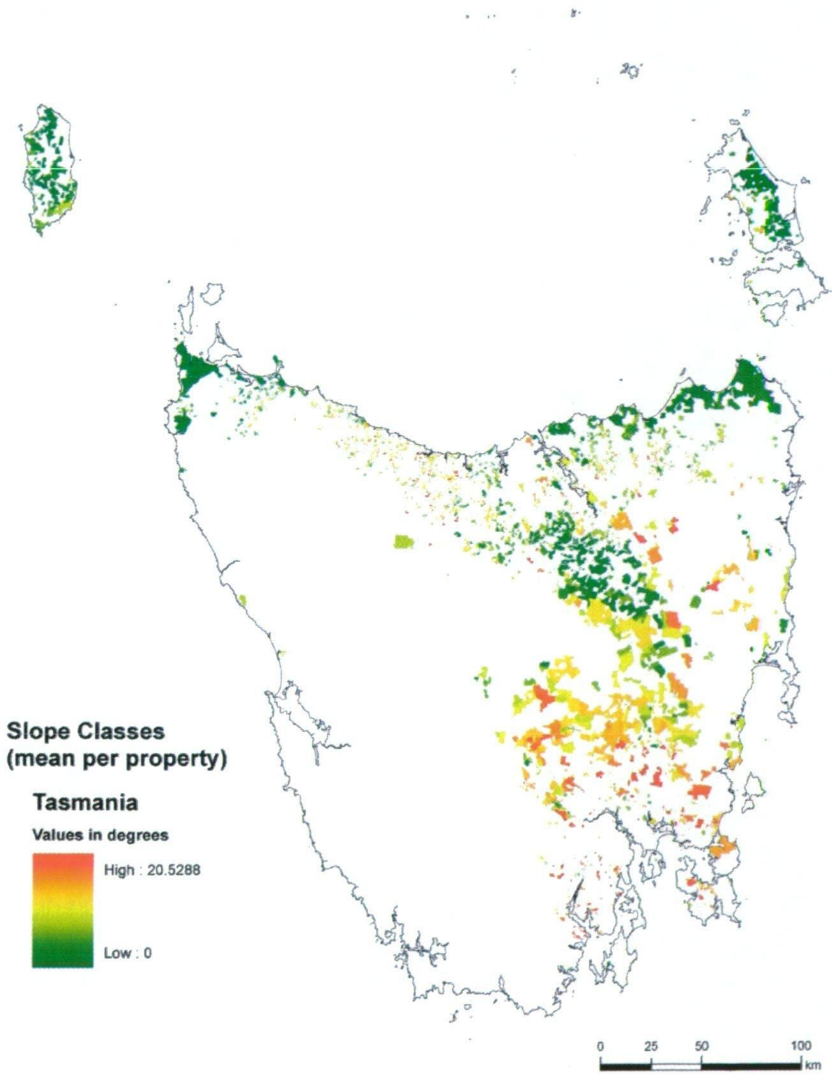

Figure 3.9 Mean slope for the areas used for beef production in Tasmania.

There were 56 different soil types associated with beef-producing properties across the State. Twenty two of these soil types accounted for a large majority (89%) of the area supporting beef production (Figure 3.10 and Figure 3.11).

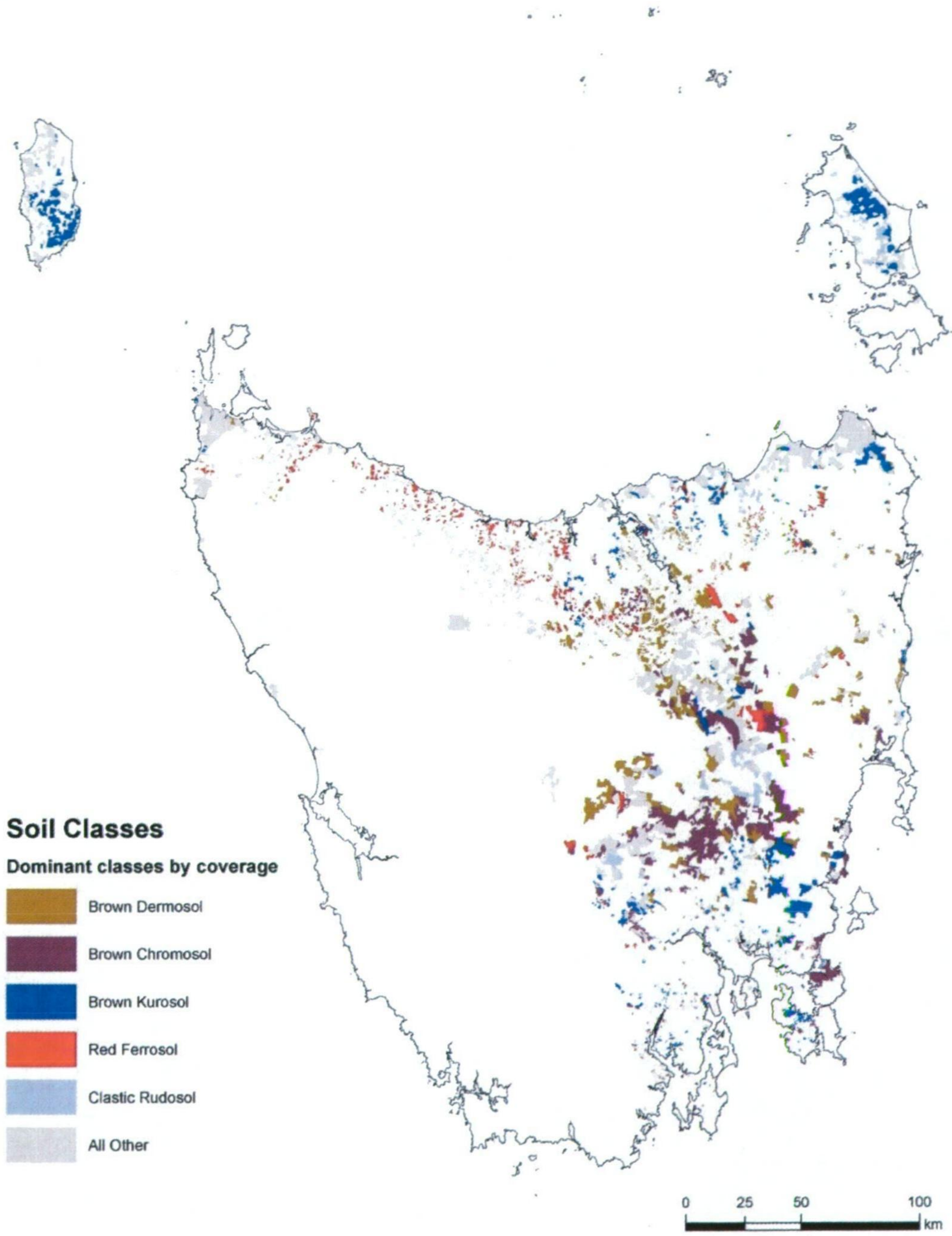

Figure 3.10 Distribution of dominant soil classes of land used for beef production in Tasmania.

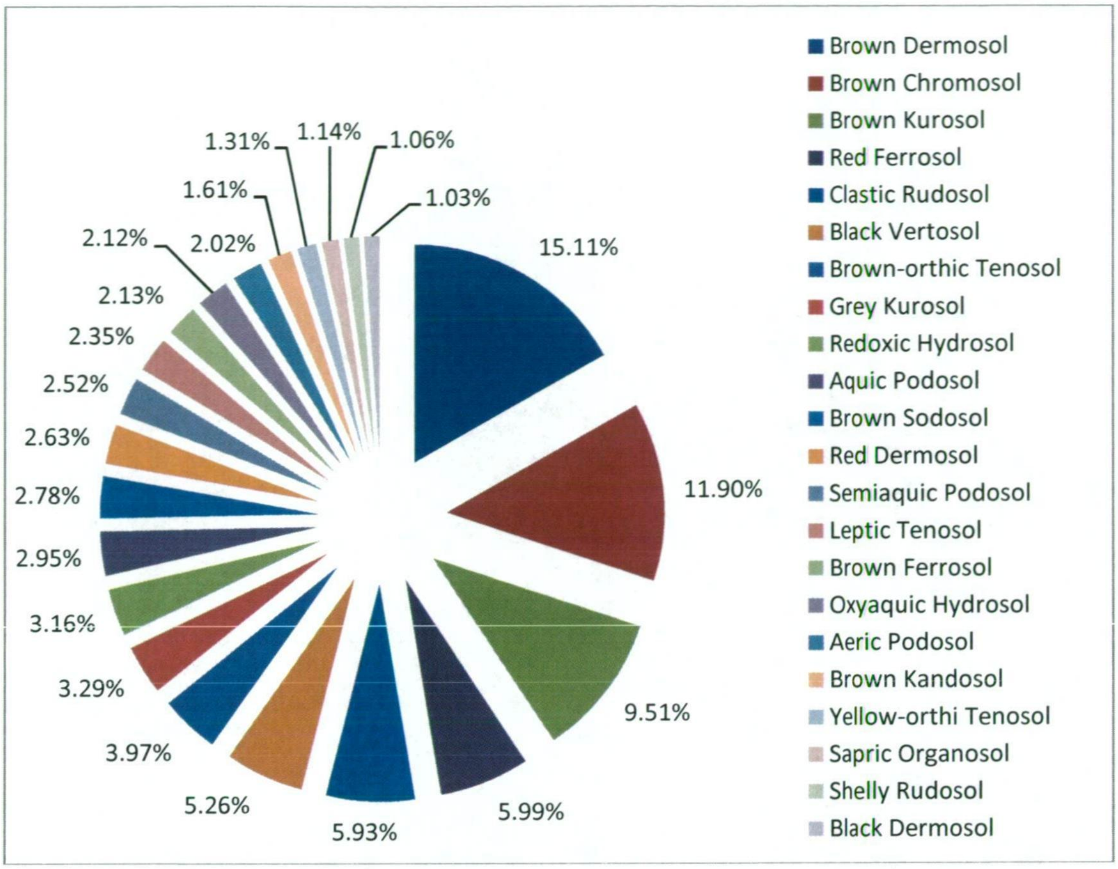

Figure 3.11 Proportion of the area used for beef production in Tasmania that is covered by the 22 dominant soil types.

The area of beef production consisted of 65 different land use classes. Most of this area (~60%) was classed as improved pastures (Figure 3.12 and Figure 3.13).

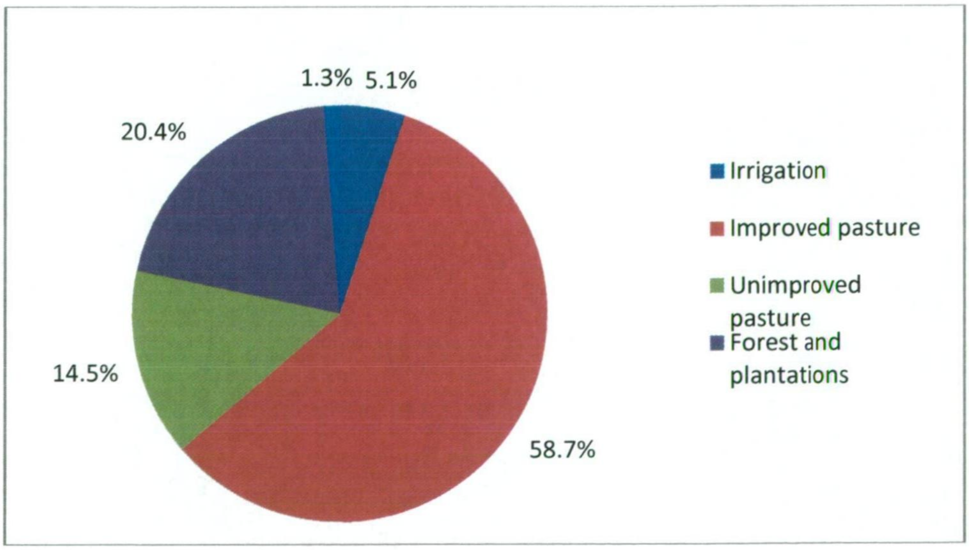

Figure 3.12 Land use allocation for the area used for beef production of Tasmania.

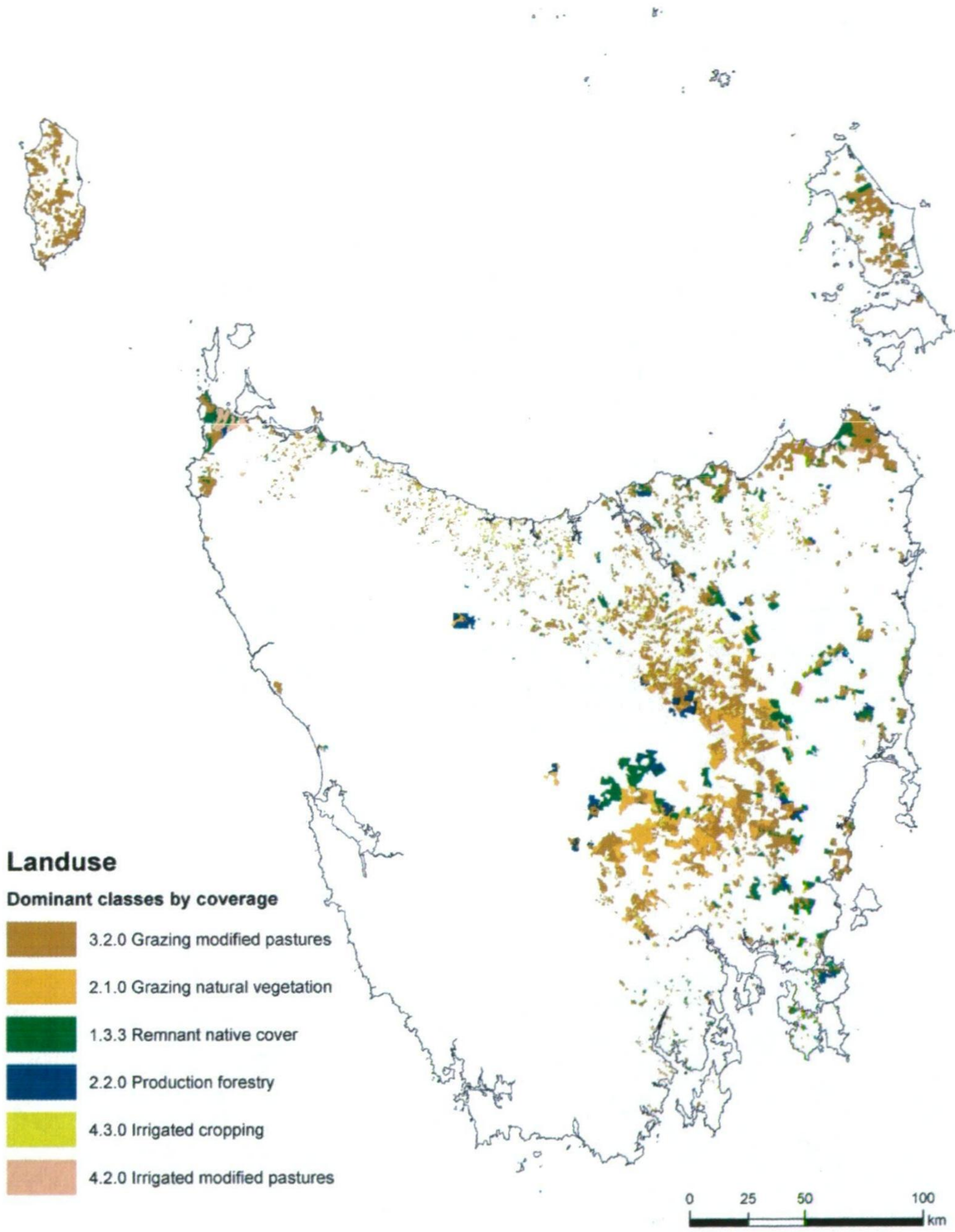

Figure 3.13 Land uses mapped for the areas used to support beef production in Tasmania.

3.3.2 Tasmanian agricultural land with the potential to support beef production

The range in mean annual rainfall and mean annual temperate for all properties currently supporting the beef industry in Tasmania was estimated to be relatively broad at 496 to 2146mm and 6.5 to 12.9^{0}C, respectively (Figure 3.6 and Figure 3.7). GIS analyses showed that 2,012,435 ha of private land on mainland Tasmania (83%) experience this range in climate – including the 768,872 ha currently used for beef production (Table 3.4). Further analyses of private land with a suitable climate for beef production showed that almost 1 million ha of this land not currently used by the industry also has suitable soil types (eg. brown dermosols, brown chromosols) and occur on shallow slopes (<15 degrees) (Table 3.4). The vegetation cover of these lands includes 486,851 ha of improved pastures and over 116,000 ha of unimproved pastures (Table 3.4). The distribution of land with the potential to support beef production was mapped at the property level across mainland Tasmania and is shown with land currently supporting beef production in Figure 3.14. The potential to expand the area used for beef production on King Island and Flinders Island was not examined in this study.

Table 3.4 Biophysical features of land with the potential to support beef production on mainland Tasmania.

Land Resource	Area (Ha)	Percentage (%)
Private land on mainland Tasmania	2,415,161	100
Land with suitable climate*	2,012,435	83
Land with suitable climate & soil types**	1,640,675	68
Land with suitable climate, soil types on slopes <15 degrees***	1,444,678	59
Land meeting requirements not supporting beef production	998,456	41
Vegetation cover of land with potential for beef production:	**998,456**	**100**
Improved pastures	486,851	48.8
Unimproved pastures	116,110	11.6
Other cover	395,495	39.6

*Suitable climate = falling within the range of mean annual temperature and rainfall estimated for beef farms in Tasmania (see Figure 3.2 & Figure 3.4); **Suitable soil types = brown dermosol, brown chromosol, brown kurosol, red ferosol, clastic rudosol (see Figure 3.11); ***slopes considered most suitable for beef farming.

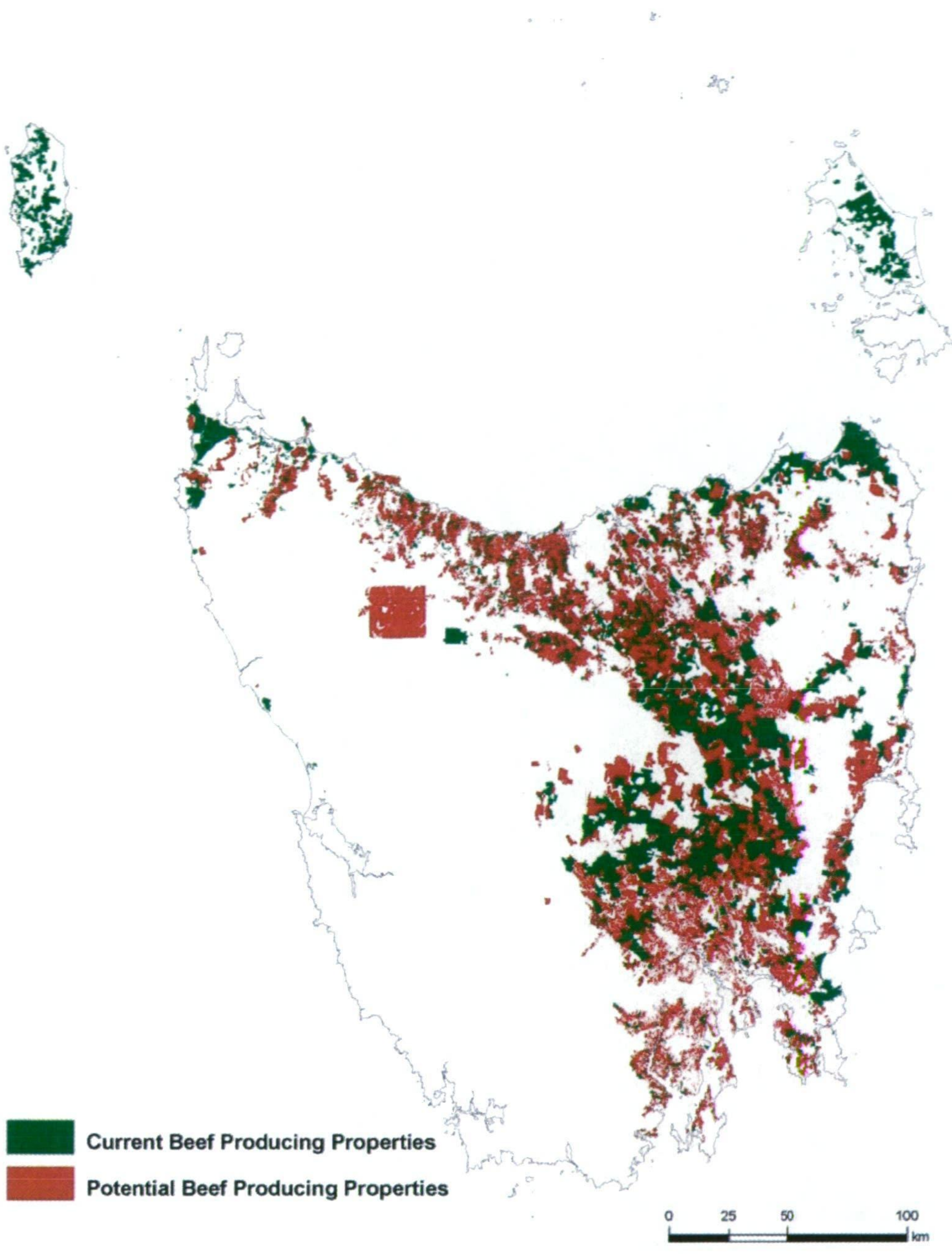

Figure 3.14 Current properties (green) supporting beef production across Tasmania and those properties (red) estimated to have the potential to do so on the main island.

3.4 Discussion

Tasmania covers an area of approximately 68,300 km^2, with nearly one third used for agricultural purposes (IRIS 2008). The landscapes used for agriculture vary markedly in terms of climate, topography, soil fertility and other environmental variables that may influence agricultural production. DPIPWE has been engaged in land capability mapping for agricultural areas in the State for over a decade. Land capability has been defined as a ranking of the ability of land to sustain a range of agricultural land uses without degradation of the land resource (e.g. Grose 1999; Moreton 1999; Moreton & Grose 1999). This assessment is based on the physical limitations and hazards of the land, potential cropping and pastoral productivity, and the versatility of the land to produce a range of agricultural goods without damage to the land base (Grose 1999). As a result of this work, approximately 2.5 million ha of private land across the State has been mapped for its capability and some 1.59 million ha or 63.6% has been identified as being most suitable for agriculture (ie. Land Classes 1-5) (Norton 2009a). It is from this base, and in the context of competing land uses, that the beef industry has selected areas to support beef production.

3.4.1 Biophysical description of the landscapes supporting the beef industry in Tasmania

Land used for beef production in Tasmania stretches from the North West and King Island across to the North East and Flinders Island and down through the East Coast and Midlands to the southern end of the State. Results from this study indicate the area used for beef production is located within the larger and more consolidated agricultural regions of the Tasmania that appear subject to less extreme climatic conditions. Grazing and beef production tend to occur on lower slopes compared to the variety of topography experienced across the overall State. Soil moisture, rainfall and temperature are all important drivers of pasture production (Pearson & Ison 1987; Hopkins 2000; Parsons & Chapman 2000). Beef properties in Tasmania generally experienced warmer, drier conditions than the State average. There was a 31% difference between the estimated average annual rainfall for the whole State and the lands used for beef production. The lower rainfall was also reflected in the lower water balance estimated for beef producing areas. As well as having a strong influence on the productivity and profitability of an enterprise; average annual rainfall, soil moisture level, and temperature can also influence many management choices - from the selection of pasture species and stocking rates to paddock design and fertiliser application (Pearson & Ison 1987; Hopkins 2000).

The soil types of farms supporting beef production were mapped as a mixture of relatively high and relatively low fertility. Six different soil types accounted for over half the total area used by the industry. Of these, brown dermosol, black vertosol and red ferrosol are relatively high in fertility (Isbell 1996; Glendinning 2000), however, all six of the soil types are considered suitable to support grazing. Some of the more fertile soils, such as red ferrosol, are commonly used for more intensive agricultural production, including cropping (ANRA 2001).

It should be noted that the available spatial data on soils do not include information on local management practices that may affect soil fertility. Hence, strictly, the categorisation of a soil type may not reflect its actual fertility. Nonetheless, the mixture of different soil types and apparent variation in soil fertility suggests that it is possible to produce beef on a range of soils. That is, productivity can be achieved through suitable knowledge and understanding of the different soil types and their optimal management (Glendinning 2000). The development and implementation of modern practices and increased knowledge of different soils can provide increased productivity and profitability (Woodrow 2001; Murray *et al.* 2007). At an industry level, the knowledge of what soil types are present can be used to assist in assessing potential productivity, identifying any likely issues such as erosion or soil degradation, and assessing the potential for management interventions to alter beef productivity.

The results indicated that improved pasture is the dominant land cover supporting beef production. Improved pastures are generally regarded as having the greatest level of productivity in high rainfall zones such as Tasmania (McIvor 2005). The majority of beef production in Tasmania is from pasture-based production systems (DPIW 2009), although a number of properties still retain unimproved pasture.

The use of mixed farming systems is increasingly common across Tasmania. For example, many farms integrate beef production with irrigated cropping as well as use pasture as part of crop rotation. The continuation, and further expansion, of the practice of incorporating livestock grazing with irrigated cropping has been identified as an opportunity for beef industry improvement (DPIW 2009).

The results of this study indicate that there is a substantial area of land used to support forest and other forms of remnant native vegetation, and plantations, on beef producing properties. The conversion of cleared agricultural land to plantation forestry is increasing in Tasmania. This change in land use is regarded as one of the potential threats to the land base of the Tasmanian beef industry (DPIW 2009). The loss of grazing land to plantations can result in land not being used to its greatest potential productivity (DPIW 2009).

3.4.2 Land with the potential to support beef production

In the order of 1 million ha of land was identified that, *prima facie*, has the potential to support beef production on the mainland of Tasmania. Furthermore, approximately half of this potential land resource already supports improved pastures that could be used for grazing by beef livestock. The large majority of this land currently supports other land uses such as dairy, sheep grazing and horticulture that may or may not provide a greater return to property owners and land managers compared to its use for beef production. Detailed analysis of the returns of the identified lands in terms of current land uses versus those for beef production was beyond the scope of the thesis. Even so, a recent report by West (2009) on the contribution of different agricultural industries to

Tasmania's economy provides higher order data to consider this question. The land area estimated to support industries such as dairy (72,000 ha), sheep (350,000 ha), horticulture (34,000 ha) and wine (1,200 ha) in Tasmania and the gross margin of production per ha (before tax and interest) suggests that some of the land with the potential to support beef production could provide a higher return if used for that purpose (West 2009). The gross margin per ha estimated for beef production was $225 compared to $150 for sheep. Furthermore, the gross margin return per ha may also be greater for beef compared to dairy depending on the scale and efficiency of dairy operation and milk prices. Approximately 10% or 103,541 ha of the land identified with potential to support beef production is estimated to currently support sheep. If the relative differences reflected in the reported gross margins per ha of beef and sheep ($225 and $150 per ha, respectively) are indicative of the situation across mainland Tasmania then higher returns could be expected with an expansion of the beef industry in certain regions. More detailed analysis of these dimensions should enable the calculation of gross margin returns at a property and regional level and, as a consequence, support the development of a comprehensive business case to test the merit of further industry expansion and land use change to beef production in the State.

3.4.3 Conclusions

This Chapter aimed to describe the range in a number of important production supporting biophysical attributes that were selected to characterise the landscapes currently supporting beef enterprises in Tasmania. The biophysical characterisation of the beef industry also allowed land with the potential to support beef production, based on their climate, soils and topography, to be mapped at a property level across the mainland of Tasmania. This body of work suggested that beef production can occur across a range of environmental gradients and that, in principle, a significant area of land could be available in Tasmania to support an expansion of the beef industry subject to land management objectives, business performance and return on investment. The research work presented in this Chapter sets the scene for the quantitative examination of the financial performance of the industry and selected focus farms outlined in Chapters 4 and 5 of the thesis.

4. Relationships between financial and environmental data and farm business performance at a beef industry level in Tasmania

4.1 Introduction

Beef enterprises are faced with an ongoing need to improve sustainability and maintain enterprise viability. Rising input prices, declining terms of trade, and competition from different land users, are currently driving the need to improve productivity and profitability (Nossal *et al.* 2008). Having accurate knowledge of the productivity and profitability of an enterprise, and understanding how these factors are inter-related, is necessary for successful and sustainable farm management (Holmes *et al.* 2008). Developing this understanding requires access to the appropriate tools and capability to identify enterprise strengths, weaknesses and areas for potential improvement.

Benchmarking provides a tool for producers to improve farming enterprises by quantifying the major factors involved in production and performance, and allowing robust comparisons of these factors over time, across different enterprises and between producers (RIRDC 2000; Ronan & Cleary 2000). Benchmarking and ongoing analysis enable the key drivers of productivity and profitability, and the strengths, weaknesses and opportunities for improvements in farm practices and performance to be identified (Johnstone 1999; RIRDC 2000).

Agriculture in Tasmania is spatially extensive and occurs across a range of landscapes where the availability of natural resources to support agriculture can vary significantly (ANRA 2007). These natural resources include land cover, soil, water and the prevailing climate that set the boundaries of potential biological productivity for any farming enterprise. GIS tools and techniques offer a quantitative means to analyse these natural resources and climatic influences (Bateman *et al.* 1999; Bateman *et al.* 2002).

The integration of spatially-based resource information with associated financial performance data provides an opportunity to examine relationships between the natural resource base of beef enterprises, their biological productivity and their profitability. Previous studies of farm performance have demonstrated the advantages that might be obtained from the integration of economic and spatial data, including a capacity to study relationships in more and finer detail (Moxey 1996; Bateman *et al.* 1999; Bateman *et al.* 2002).

This Chapter reports on the integration and analysis of spatial and financial benchmarking data from 27 beef enterprises in Tasmania to determine the factors affecting profitability and productivity. The aims of the Chapter were to:

- Identify correlations between financial and environmental data in relation to farm business performance
- Consider the relevance of correlates to farm productivity and business performance
- Examine the key performance indicators driving farm profitability
- Assess the representativeness of the focus beef enterprises compared to the Tasmanian beef industry, overall.

4.2 Methods

The methods consisted of five main steps - selection of financial and environmental factors to be examined, recruitment of beef producers, collection of the financial benchmarking and farm management data, compilation of the spatial data on natural resources for each property, and data analysis and synthesis.

4.2.1 Selection of financial and environmental factors to be examined

Based on a review of the literature, financial variables were selected to profile the productivity and profitability of Tasmanian beef enterprises, including associated revenue, expenses, risk and solvency measures. These variables are commonly measured parameters produced for many farm financial analyses in Australia (Johnstone 1999; Newman & Chapman 2001; McEachern *et al.* 2005; Holmes *et al.* 2008). Similarly, a review of the literature was used to select biophysical variables suitable for describing the significant components of the natural resource base of beef producing in Tasmania. The selected financial, productivity and biophysical (spatial) variables analysed are summarised in Table 4.1. The sources for biophysical spatial data follow those listed earlier in Chapter 3.

Table 4.1 List of key variables used in data analysis, including a summary of calculations and definitions, the hypothesised relationship between each variable and enterprise profitability, the level of accepted model variability, and relevant references.

Variable[1]	Abbreviation	Units	Calculation/definition	Expected correlation with profitability	Accepted variability of model prediction	Reference[3]	Notes
Effective beef area[#]	EBA	ha	Area of property used for beef enterprise	?	NA	(Purdy *et al.* 1997; McEachern *et al.* 2005; DPIW 2009)	
Return on assets[#]	ROA	%	[(Operating profit-lease on lands and building)/total assets at start of year] x 100	+	3%	(Holmes *et al.* 2008; ABARE 2009)	Calculated 4-year average values Can also include capital gains where these are calculated from the change in capital values of all assets between the start and end of the year after allowing for depreciation and any additional introduced capital.
Return on equity[#]	ROE	%	[(operating profit-total financing costs)/equity at start of year] x 100	+	4%	(Holmes *et al.* 2008; ABARE 2009)	Calculated at 4-year average values Can also be calculated including capital gains (see ROA notes)
Operating profit[#]	OP	$	Operating surplus-operating profit adjustments	+	$62,300		Adjustments include 'book' or non-operating adjustments for expenses and revenue
Operating profit per ha[#]	OP/ha	$/ha	OP/EBA	+	$112		Accounts for the difference in profitability associated with enterprise size
Operating profit margin[#]	OP margin	%	(OP/Gross revenue)x100	+	10%	(Holmes *et al.* 2008)	Calculates the proportion of gross revenue that is kept as profit
Cost of production per kg of meat (lwt)[#]	COP	$/kg	[(gross operating expenses x product revenue)/gross revenue]/(kilograms of product sold + change in lwt on hand)	–	$1.05	(Newman & Chapman 2001; Giumelli 2006; Holmes *et al.* 2008)	
Stocking rate	SR	DSE/ha	Total DSE/EBA	+	5.6	(Salmon *et al.* 2005; Warn *et al.* 2006; Holmes *et al.* 2008)	1 DSE is equal to a 40 kg weather
Labour efficiency[#]		DSE/FTE	Total DSE/number of full time equivalent staff	+	692	(Johnstone 1999; Newman & Chapman 2001; Holmes *et al.* 2008)	FTE is determined based on their employment status. Full time employees are regarded as 1 FTE. 50 hours/week is used to calculate the fraction of FTE that part time employees are.
Total assets per ha[#]		$	Total value of land, buildings and livestock/EBA	+	$4781	(Johnstone 1999)	Calculated at both 4-year average values and at market values
Equity percentage[#]	Equity%	%	(Equity/total assets) x 100	+	15.75%		
Gross operating expenses[#]	GOE	$	Total operating expenses-feeds and supplements on hand-imputed labour and management-depreciation-other expenses adjustments	-	Per ha: $193.02 Per DSE: $8.58	(Holmes *et al.* 2008)	Can also be calculated on a per DSE and per ha basis
Change in equity[#]		$	Equity at end of year-equity at start of year	?	$395,830		Calculated at 4-year average values

Core per DSE cost#		$/DSE	(costs of animal health + breeding + electricity + 50% of nitrogen fertiliser + freight + other expenses + 50% of repairs and maintenance + 50% of vehicle expenses + 50% of depreciation)/total DSE	-	$2.40		'Other expenses' are any expenses that cannot be reasonably allocated to any other area
Core per ha costs#		$/ha	(costs of administration + 50% of nitrogen fertiliser + phosphates and all other fertilisers + irrigation + pasture maintenance and renovation + 50% of repairs and maintenance + standing charges + 50% of vehicle expenses + weed and pest + 50% of depreciation)/EBA	-	$100.19		Standing charges include insurance, industry levies, licenses, permits and rates
Financing costs as percentage of gross revenue#		%	(interest + bank charges + loan fees + lease fees and rentals)/gross revenue	-	19.84%		Calculates the proportion of revenue that is used for payment of financing costs
Area of land use groups##		%	(Area of specified land use/total area) x 100	+		(Lodge 1994; Lodge *et al.* 1998; Johnstone 1999)	Calculated for each of the land use groups outlined in Table 3.4
Area of relatively low fertility soils##		%	(Area of relatively low fertility soils/total area) x 100	-		(Donnelly *et al.* 1998; McEachern *et al.* 2005)	
Area of relatively high fertility soils##		%	(Area of relatively high fertility soils/total area) x 100	+		(Donnelly *et al.* 1998; McEachern *et al.* 2005)	
Average lwt of beef sold#		Kg	Total lwt of beef sold/total number of stock sold	+	108kg	(Holmes *et al.* 2008)	
Total lwt of beef produced per ha and per DSE#		Kg/ha Kg/DSE		+	Per ha: 100kg Per DSE: 16kg	(Salmon *et al.* 2005; Warn *et al.* 2006; SheepCRC 2007; Holmes *et al.* 2008)	
Total lwt of beef produced per ha per 100mm rainfall#&###	Beef/ha/100mm	Kg/ha/100mm	Total lwt of beef produced per ha/rainfall	+	35.1kg	(McEachern *et al.* 2005; Holmes *et al.* 2008)	Rainfall was calculated for each property as the total for the 2006/2007 financial year from the nearest weather station[4]
Management and staff costs per DSE#		$/DSE		-	$3.77	(Holmes *et al.* 2008)	Includes imputed labour and management costs

1 Data source. # Benchmarking ## GIS ### Bureau of Meteorology 2 hypothesised correlation of variable with enterprise profitability. ? not defined or inconclusive, + positive correlation, - negative correlation 3 Reference relevant to expected correlation with profitability and accepted level of model variability 4 Sourced from http://www.bom.gov.au/climate/data/weather-data.shtml

4.2.2 Recruitment of beef producers

Involvement of beef producers in the research was voluntary. Approvals were obtained from the University of Tasmania's Human Research Ethics committee prior to commencement. A commercial benchmarking company called Red Sky Agricultural Pty Ltd (Red Sky, www.redsky.com.au accessed October 2009) was contracted by TIAR to collect the financial performance measures. The only restriction to acceptance of a producer's participation was a requirement to have commercial numbers of beef cattle. This was set at a minimum of 50 head of beef cattle, as per the ABS definition of a commercial beef enterprise (ABS 1983 Cat. No. 1201.0). Properties included a combination of beef, beef and sheep, and grazing and cropping farms, however the financial benchmarking data presented is specific to the beef enterprise. Participating enterprises were referred to as focus farms.

Initially, the collection of financial data by Red Sky was attempted using commercial accountants as intermediaries. However, this approach proved ineffective and so direct farmer recruitment was undertaken. Promotion was undertaken through presentations at red meat producer meetings and to industry representative bodies. Other recruitment procedures involved Red Sky, TIAR, and DPIPWE staff. They included newspaper articles; radio interviews and promotion; mail outs to producers on pre-existing TIAR and DPIPWE Tasmania networks; articles in government and industry magazines or newsletters; internet promotional web sites; recruitment drives at agricultural field days and shows; and presentations at an annual Accountant's Congress in Tasmania.

4.2.3 Collection of the financial benchmarking and farm management data

Participating producers submitted their financial data for years 2006/07 and 2007/08 to Red Sky which processed them using a commercial data analysis program (Acclipse BenchmarkIT, version 4.2.51, 2002, Acclipse Ltd, Christchurch, New Zealand) to produce an overview of the financial performance of each enterprise, as well as summary financial performance values for the average and the top quartile of farms for each financial year. In light of the need for accurate data for effective benchmarking (Le Sueur 1997), Red Sky completed a series of cross checks to ensure internal consistency and data set validity.

Additional data relating to farm management practices was obtained from a written participant survey. The development of the farm management questions used in the survey was based on information that was identified in the literature as being important to beef production that could be collected from producers, but that was not collected by Red Sky. A prototype survey was sent to five producers to test that the questions were clear, unambiguous, and that the desired information could be readily collected. Farm management surveys were sent by Red Sky to the 27 participating producers together with their benchmarking reports. Follow-up phone calls were often necessary to ensure the surveys were returned punctually. All benchmarking and additional data was stored in a Microsoft Excel spreadsheet (versions 2003 and 2007, Microsoft Corporation, www.microsoft.com /en/au/default.aspx accessed December 2009).

4.2.4 Compilation of the spatial data on natural resources for each property

Participating producers provided the PIDs relevant to their beef enterprise. These PIDs were used as the key spatial property locater for compiling the spatial database on the natural resources of each beef property. The spatial data organisation and analyses were undertaken using the GIS technology (hardware and software) described in Chapter 3. The process used was exactly the same except that the data extraction process was conducted for each individual property.

4.2.5 Data analysis and synthesis

In order to be able to compare all enterprises or focus farms equally, average and top quartile financial benchmarks were calculated on a weighted average (on land area) basis. Allocation of focus farms to performance ranking was based on Return on Capital (ROC expressed as a %). ROC was calculated as operating profit divided by total assets utilised in the business. Operating profit (OP) did not include any lease/rental expenses or any debt finance. The total value of all assets utilised in the business included the value of all owned and leased assets. Thus, the summary results presented for the top quartile of participating benchmarked enterprises represented the value for the group based on the ROC rather than the individual performance indicators. This enabled the results to be studied in the 'Read Down' method when comparing focus farm enterprises.

Soil types and land use classes for each beef property were derived and grouped following the methods outlined in Chapter 3.

Statistical analysis was performed using stepwise regression analysis in SAS/STAT software (Version 9.1, 2002-2003, SAS Institute Inc., Cary, NC, USA). A forward stepwise regression procedure was used in which one variable was added to the model at a time and was retained where the F value was < 0.2. Variables already in the model were dropped if they obtained an F value > 0.1. The final model was summarised using adjusted R^2 values and parameter estimates. Data used in the model were for the 2006/2007 financial years ($n = 27$ enterprises) and were tested for normality prior to analysis using quantile-quantile and residual plots in SAS. The variable Total assets per ha was normalised using a log transformation. Developed models were tested for extreme values and colinearity using the influence diagnostics of the regression procedure (Proc Reg) of SAS. The representativeness of the focus farms was conducted using one sample t-tests to determine if the focus farm mean differed significantly ($P < 0.05$) from the State-wide biophysical data for beef enterprises presented in Chapter 3. Tested variables in the models included, as appropriate, the key drivers of profitability for the beef industry identified during the literature review (Effective beef area (EBA), SR, kilograms of beef produced per hectare and per 100mm rainfall, average lwt and value of animals sold, labour efficiency, see Table 4.1), value of managed land (total asset value per ha, percent improved pastures), enterprise management (level of equity, supplementary feeding decisions, full time equivalent staff (FTE) and percentage time on the beef enterprise within the whole business), and the spatial descriptors for the enterprise (long term rainfall, average, maximum and minimum temperatures; water balance, slope, percentage area of soil types based on their relative level of fertility; and the four classes of land use). The general models presented potentially include all terms, whereas the spatial model contains only those terms related to the spatial descriptors.

Semi-quantitative model evaluation was conducted subsequently using 2007/2008 data ($n = 10$ enterprises), where the developed model was used to predict the results for 2007/2008. The predicted results were then analysed to determine if they were significantly different to the actual results. This was done using paired two sample t-tests in which predictions and observed values for individual focus farms were compared. Models that did not have a significant difference between the predicted and actual values ($P > 0.05$) were then tested by comparing the model's 95% confidence limits to a previously defined accepted level of variation. The accepted level of variation was defined based on the measured standard deviation of each variable, combined with commercially relevant differences as identified from the literature review. The upper and lower confidence limits were based on the 2006/2007 data and calculated from the output statements of the regression procedure in SAS. A model's predictive capacity was deemed acceptable where the model's confidence limits were consistent with the accepted variability range and the majority of the predicted points for 2007/2008 fell within the confidence limits.

4.3 Results

4.3.1 Summary of benchmarked beef enterprise performance

The average, top quartile, minimum and maximum values for key benchmarking variables are presented in Table 4.2. The more profitable enterprises had a numerically higher level of production per ha, lower COP and core per DSE costs, but a higher core per ha costs.

Table 4.2 Selected benchmarks for the average and top quartile enterprises and the range of values recorded for participating focus farm enterprises

Variable	Average	Top Quartile	Min	Max
Total DSE	5856	5182	402	20229
Effective beef area (ha)	429.3	302.7	50	2028
Stocking rate (DSE/ha)	13.6	17.1	4.9	27.7
Average beef value ($/kg)	1.45	1.42	0.94	1.8
Average lwt of beef sold (kg)	427.6	539.7	300	705
Total lwt beef sold per DSE (kg/DSE)	22.7	30.7	7.5	79.9
Average value of beef sold per DSE ($/DSE)	33	44	7	118
Total weight of beef sold per hectare (kg/ha)	309.8	526.2	89.7	1331.2
Total lwt of beef produced per hectare (kg/ha)	246	435.3	67.8	888.6
Gross operating expenses per hectare ($/ha)	363	420	143	902
Gross operating expenses per DSE ($/DSE)	26.63	24.52	15.8	54.12
Return on assets (%)	-0.1	2	-6.8	6.9
Return on assets including capital gains (%)	7.8	15.4	-32.1	88.9
Return on equity (%)	-1.0	1.2	-24.9	7.9
Return on equity including capital gain (%)	7.8	16.5	-40.2	109.3
Operating profit margin (%)	0.6	29.8	-1284.5	66.1
Operating profit per hectare($/ha)	2	178	-406	703
Total assets per hectare ($/ha)	3751	7570	654	21456
Equity percentage (%)	88.2	88.5	37.2	103.4
Change in equity ($)	186436	372842	-260259	1727200
Financing costs as percentage gross revenue (%)	13.9	13.6	0	309.7
Cost of Production ($/kg)	1.48	0.96	0.47	5.06
Core per DSE cost ($/DSE)	5.87	4.96	2.74	12.82
Core per hectare cost ($/ha)	146	172	34	471
Management and staff costs per DSE ($/DSE)	7.32	8.33	2.05	21.31
DSE per full time staff equivalent	6653	5869	0	24420
Feed and supplements (Total) ($)	15855	5968	0	101990
Feed and supplements per DSE ($/DSE)	2.75	1.15	0	16.05
Fertiliser (Total) per hectare ($/ha)	55	66	3	179

- Nitrogen ($/ha)	9	19	0	113
- Phosphate and all other fertiliser ($/ha)	46	47	3	112

*Average and top quartile values were on a weighted average basis. n = 27 enterprise

4.3.2 Profitability

Increasing ROA was largely related to a reduced COP (Table 4.3). The developed model was able to predict the ROA for 2007/2008 with no significant difference between the actual and predicted values. However, given the proximity of the confidence limits to the accepted variability, the model can only be used as a guide at an industry level (Figure 4.1). The spatial variables explaining variability in ROA included area of relatively low fertility soils, area of improved pasture, area of other land uses, maximum temperature, and slope (Table 4.4).

Table 4.3 A general model developed using 2006/07 data relating enterprise performance and spatial variables to return on assets (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.08	0.038		#
Cost of production ($/kg)	-0.014	0.0010	0.39	***
Area of improved pasture (%)	$+4\times10^{-4}$	1.1×10^{-4}	0.10	**
Area of relatively low fertility soil (%)	-5×10^{-4}	1.1×10^{-4}	0.07	***
Area of other land uses (%)	+0.0125	3.6×10^{-3}	0.03	**
Maximum temperature (^{O}C)	+0.008	3.5×10^{-3}	0.02	*

Adjusted model R^2 = 0.77, P<0.0001. # P < 0.10, * P <0.05, ** P < 0.01, *** P < 0.001.

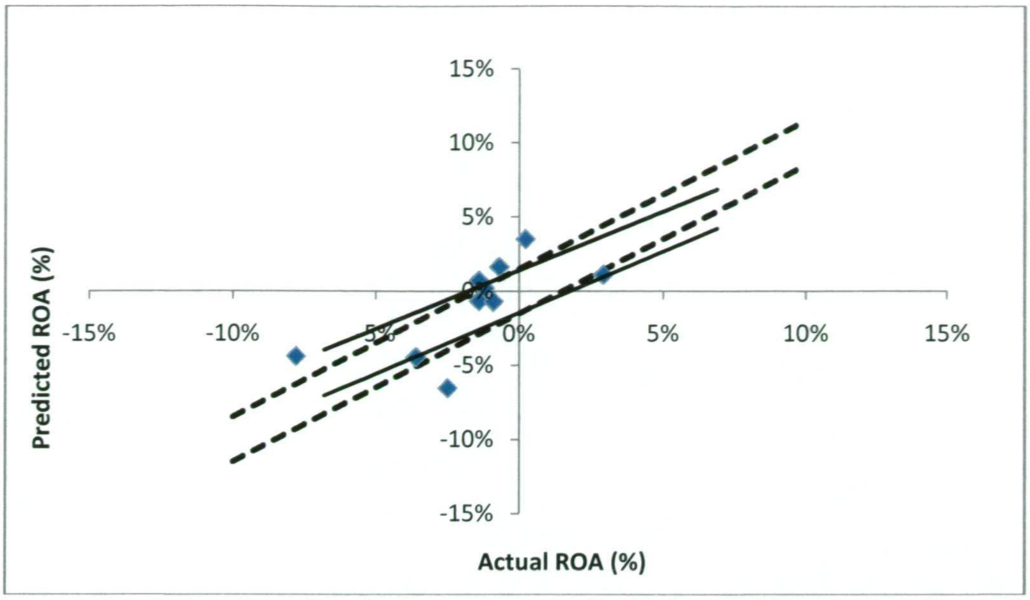

Figure 4.1 Actual and predicted return on assets (ROA) for 2007/2008 using the model generated from 2006/07 values. Solid line - upper and lower 95% confidence limits of the model. Dashed line – predetermined accepted variability range.

Table 4.4 Spatial model developed using 2006/07 data relating spatial variables to return on assets (%)for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.22	0.0612		**
Area of relatively low fertility soil (%)	-6.7×10^{-4}	1.39×10^{-4}	0.23	***
Area of improved pasture (%)	$+5.5 \times 10^{-4}$	1.56×10^{-4}	0.16	**
Area of other land uses (%)	+0.017	4.8×10^{-3}	0.11	**
Maximum temperature (^{O}C)	+0.0167	4.99×10^{-3}	0.11	**
Slope (degrees)	$+3.28 \times 10^{-3}$	1.67×10^{-3}	0.06	#

Adjusted model R^2 = 0.60, P = 0.0001 # P < 0.10, ** P < 0.01, *** P < 0.001.

When ROA, including capital gains (ROA_{CG}), was examined the only significant explanatory variable was average lwt of beef sold, which accounted for only 25% of variability (Table 4.5). The developed model was not capable (P = 0.01) of predicting the actual ROA_{CG} values for 2007/2008. The only variable included in the model examining the effect of spatial attributes was slope (ROA_{CG} = -0.0271 x Slope + 0.204, P = 0.03), accounting for 15% of the variation in ROA_{CG}.

Table 4.5 General model developed using 2006/07 data relating enterprise performance and spatial variables to return on assets including capital gains (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.332	0.1405		*
Average lwt of beef sold (kg)	$+9.84 \times 10^{-4}$	3.139×10^{-4}	0.28	**

Adjusted model R^2 = 0.25, P = 0.004 * P <0.05, ** P < 0.01.

Explanatory variables significantly influencing ROE included equity%, COP, the area of relatively low soil fertility, the area of improved pasture, and the labour efficiency (Table 4.6). The developed model accounted for 73% of variation in ROE. Predicted ROE values for 2007/2008 were not significantly different (P = 0.08) to the actual ROE measured. However the confidence limits for this model were greater than the accepted variability. The model has limited utility for predicting the ROE, for individual focus farms this model would not be sufficiently accurate, but could be used as a guide for industry overall (Figure 4.2). Area of relatively low fertility soils and maximum temperature were significantly related to ROE (Table 4.7).

Table 4.6 General model developed using 2006/07 data relating enterprise performance and spatial variables to return on equity (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.2	0.05		***
Equity percentage (%)	+0.225	0.0409	0.41	***
Cost of production ($/kg)	-0.022	6.04×10^{-3}	0.23	**
Area of relatively low fertility soils (%)	-5.3×10^{-4}	1.98×10^{-4}	0.06	*
Area of improved pasture (%)	$+4.2 \times 10^{-4}$	2.12×10^{-4}	0.06	#
DSE/FTE	$+2.7 \times 10^{-6}$	1.52×10^{-6}	0.03	#

Adjusted model $R^2 = 0.73$, $P<0.0001$ # $P < 0.10$, * $P <0.05$, ** $P < 0.01$, *** $P < 0.001$.

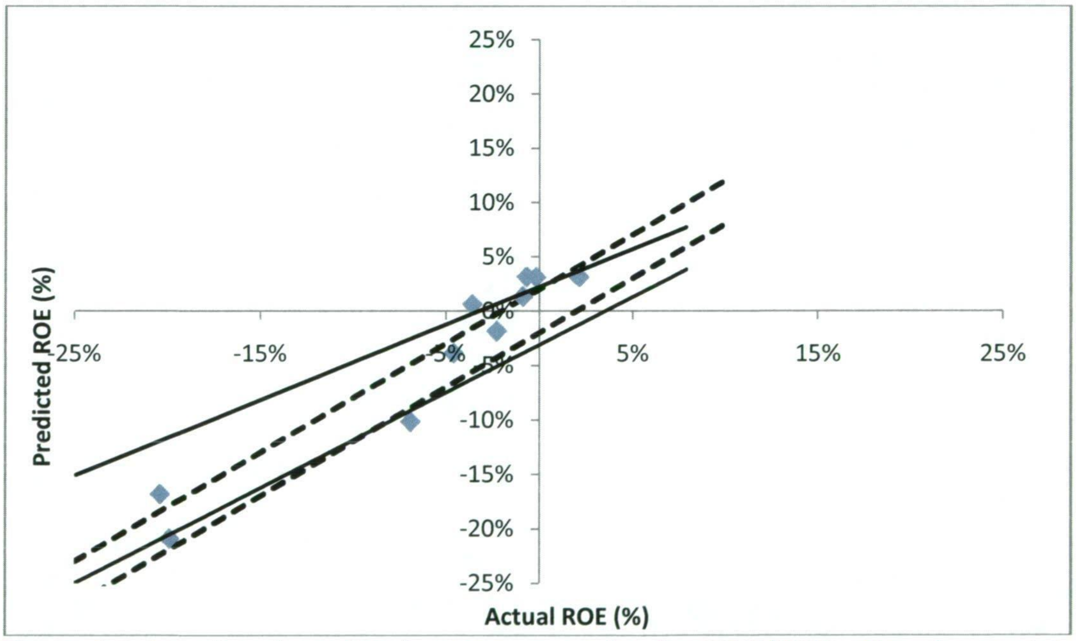

Figure 4.2 Actual and predicted return on equity for 2007/2008 using the model generated from 2006/07 values. Solid line - upper and lower 95% confidence limits of the model. Dashed line – predetermined accepted variability range.

Table 4.7 Spatial model developed using 2006/07 data relating spatial variables to return on equity (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.26	0.113		*
Area of relatively low fertility soils (%)	-1.2×10^{-3}	3.3×10^{-4}	0.19	**
Maximum temperature (^{O}C)	+0.025	0.0103	0.35	*

Adjusted model $R^2 = 0.30$, P = 0.005 * $P < 0.05$, ** $P < 0.01$.

When capital gains are added (ROE_{CG}), the model for ROE_{CG} included average lwt of beef sold, total lwt of beef produced per ha and SR (Table 4.8). This model accounted for 45% of variation in ROE_{CG} during 2006/2007 and it could not ($P < 0.01$) predict ROE_{CG} for 2007/2008. Slope was the only spatial variable to be related to ROE_{CG} ($ROE_{CG} = -0.0316 \times$ Slope + 0.225, $R^2 = 0.13$, P = 0.03).

Table 4.8 General model developed using 2006/07 data relating enterprise performance and spatial variables to return on equity including capital gains (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-0.70428	0.16885		***
Average lwt of beef sold (kg)	$+1.57 \times 10^{-3}$	4.41×10^{-4}	0.29	**
Total lwt of beef produced per hectare (kg/ha)	-7.41×10^{-4}	2.538×10^{-4}	0.08	**
Stocking rate (DSE/ha)	+0.0219	8.13×10^{-3}	0.15	*

Adjusted model $R^2 = 0.45$, P = 0.0007 * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Less than 45% of the variation in change in equity could be explained by the developed model, which included the effects of average lwt of beef sold, area of other land uses, and kg/ha/100mm (Table 4.9). There was a significant difference ($P < 0.001$) between the predicted and actual values when this model was used to predict the change in equity for the 2007/2008 financial year.

Table 4.9 General model developed using 2006/07 data relating enterprise performance and spatial variables to change in equity ($) for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	-899693	263495		**
Average lwt of beef sold (kg)	+3031.66	729.452	0.33	***
Area of other land uses (%)	+103173	49528	0.08	*
Total lwt produced per hectare per 100mm of rainfall (kg/ha/100mm)	-727.78	379.961	0.09	#

Adjusted model R^2 = 0.43, P = 0.001 # P < 0.10, * P <0.05, ** P < 0.01, *** P < 0.001.

OP/ha was correlated to COP, average lwt of beef sold, and proportion of time spent solely on beef production (Table 4.10). The available data was insufficient to test this model for 2007/2008.

Table 4.10 General model developed using 2006/07 data relating enterprise performance and spatial variables to operating profit per hectare ($) for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	-118.8	211.23		0.58
Cost of production ($/kg)	-127.05	33.174	0.51	**
Average lwt of beef sold (kg)	+1.1	0.35	0.18	**
Proportion of time spent on beef enterprise (%)	-1.95	0.982	0.06	#

Adjusted model R^2 = 0.70, P<0.0001 n=20 enterprises # P < 0.10, ** P < 0.01.

4.3.3 Efficiency

Over half (56%) the variability in beef produced per ha was explained by the developed model, incorporating average lwt of beef sold, SR, and slope (Table 4.11). Although there was no significant difference between the actual and predicted values for

2007/2008 (P = 0.10), with a predetermined accepted variability of 100kg/ha the model could not predict the beef production per ha with accuracy. Analysis of spatial variables related 24% of variation in production per ha to area of relatively low fertility soils and minimum temperature (Table 4.12).

Table 4.11 General model developed using 2006/07 data relating enterprise performance and spatial variables to beef produced per hectare (kg lwt/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-463.9	139.74		**
Average lwt of beef sold (kg)	+1.019	0.2972	0.45	**
Stocking rate (DSE/ha)	+16.24	5.697	0.11	**
Slope (degrees)	+17.22	9.284	0.06	#

Adjusted model R^2 = 0.56, P<0.0001 # P < 0.10, ** P < 0.01.

Table 4.12 Spatial model developed using 2006/07 data relating spatial variables to beef produced per hectare (kg lwt/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+432.8	61.57		***
Area of relatively low fertility soils (%)	-3.06	1.15	0.22	*

Adjusted model R^2 = 0.24, P = 0.01, * P <0.05, *** P < 0.001.

The amount of beef sold per ha was related to the total value of assets, the level of fertiliser application per ha and the area of improved pasture (Table 4.13). Based on an accepted variability of 100kg/ha this model was not capable of predicting the expected amount of beef sold for 2007/2008. On a per DSE basis, lwt sold was related to kg/ha/100mm (Table 4.14). When only spatial variables were analysed the developed model included area of relatively low fertility soils and the area of improved pasture (Table 4.15).

Table 4.13 General model developed using 2006/07 data relating enterprise performance and spatial variables to total beef sold per hectare (kg lwt/ha) for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	+113.99	95.326		0.24
Total assets per hectare (start of year at 4 year average values) ($)	+0.048	0.0064	0.68	***
Total fertiliser expenses per ha	+2.84	0.728	0.12	***
Area of improved pasture (%)	-2.7	0.98	0.05	*

Adjusted model R^2 = 0.90, P<0.0001, * P <0.05, *** P < 0.001.

Table 4.14 General model developed using 2006/07 data relating enterprise performance and spatial variables to total lwt of beef sold per DSE (kg lwt/DSE) for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	+3.44	3.497		0.34
Total lwt of beef produced per hectare per 100mm rainfall (kg/ha/100mm)	+0.055	0.0108	0.64	***

Adjusted model R^2 = 0.62, P<0.0001, *** P < 0.001.

Table 4.15 Spatial model developed using 2006/07 data relating spatial variables to total lwt of beef sold per DSE (kg lwt/DSE) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+43.6	8.40		***
Area of relatively low fertility soils (%)	-0.19	0.088	0.15	*
Area of improved pasture (%)	-0.17	0.097	0.10	#

Adjusted model R^2 = 0.18, P = 0.03 # P < 0.10, * P <0.05, *** P < 0.001.

Water balance, area of improved pasture and proportion of equity explained 38% of variability in core per DSE costs (Table 4.16). When only spatial variables were analysed water balance and the area of improved pasture remained influential in the model (core per DSE costs = 12.498 x Water Balance - 0.032 x area of improved pasture - 1.01, R^2 = 0.26, P = 0.04). Core per ha costs were positively related to SR and beef/ha/100mm (Table 4.17). A model examining spatial attributes identified area of irrigated land and long term rainfall as influencing core per ha costs (Table 4.18).

Table 4.16 General model developed using 2006/07 data relating enterprise performance and spatial variables to core per DSE costs ($/DSE) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+2.737	4.3354		0.5
Water balance	+14.34	5.007	0.16	**
Area of improved pasture (%)	-0.036	0.0129	0.15	*
Equity percentage (%)	-5.76	2.412	0.14	*

Adjusted model R^2 = 0.38, P = 0.029, * P <0.05, ** P < 0.01.

Table 4.17 General model developed using 2006/07 data relating enterprise performance and spatial variables to core cost per hectare ($/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-25.2	41.50		0.5488
Stocking rate (DSE/ha)	+9.13	2.95	0.45	**
Total lwt of beef produced per hectare per 100mm rainfall (kg/ha/100mm)	+0.88	0.473	0.07	#

Adjusted model R^2 = 0.48, P = 0.0001 # P < 0.10, ** P < 0.01.

Table 4.18 Spatial model developed using 2006/07 data relating spatial variables to core cost per hectare ($/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-28.5	59.42		0.6358
Area of irrigated land (%)	+3.47	0.970	0.25	**
Annual rainfall (long term) (mm)	+0.186	0.0611	0.46	**

Adjusted model R^2 = 0.41, P = 0.0007, ** P < 0.01.

While estimated water balance was the only spatial variable identified as being significantly related to DSE/FTE, it only accounted for 12% of the variability in DSE/FTE (Table 4.19). Management and staff costs per DSE were related to the maximum temperature, area of relatively low fertility soils and water balance (Table 4.19).

Table 4.19 Spatial model developed using 2006/07 data relating spatial variables to labour efficiency (DSE/FTE) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+25230	8398		**
Water balance	-22410	10644	0.15	*

Adjusted model R^2 = 0.12, P = 0.05, * P <0.05, ** P < 0.01.

Table 4.20 Spatial model developed using 2006/07 data relating spatial variables to management and staff costs per DSE ($/DSE) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+14.6	11.22		0.21
Maximum temperature (^{0}C)	-2.0	0.65	0.17	**
Area of relatively low fertility soils (%)	+0.067	0.0231	0.15	**
Water balance	+16.8	9.32	0.09	#

Adjusted model R^2 = 0.32, P = 0.007 # P < 0.10, ** P < 0.01.

4.3.4 Risk

COP was negatively related to total lwt produced per ha, EBA, and DSE/FTE (Table 4.21). The predicted COP for 2007/2008 was not significantly different (P = 0.37) to the actual COP. When the confidence limits and an accepted variability of $1.00/kg for the developed model was graphed with the predicted and actual values for 2007/2008, the model was not sufficiently accurate to predict COP (Figure 4.3). There were no spatial variables eligible to enter the model.

Table 4.21 General model developed using 2006/07 data relating enterprise performance and spatial variables to cost of production per kilogram (lwt) of meat ($/kg) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+3.64	0.449		***
Total lwt of beef produced per hectare (kg/ha)	-3.6×10^{-3}	7.7×10^{-4}	0.35	***
Effective beef area (ha)	-6.2×10^{-4}	3×10^{-5}	0.09	#
DSE/FTE	-6.4×10^{-5}	3.63×10^{-5}	0.07	#

Adjusted model R^2 = 0.44, P = 0.0009 # P < 0.10, *** P < 0.001.

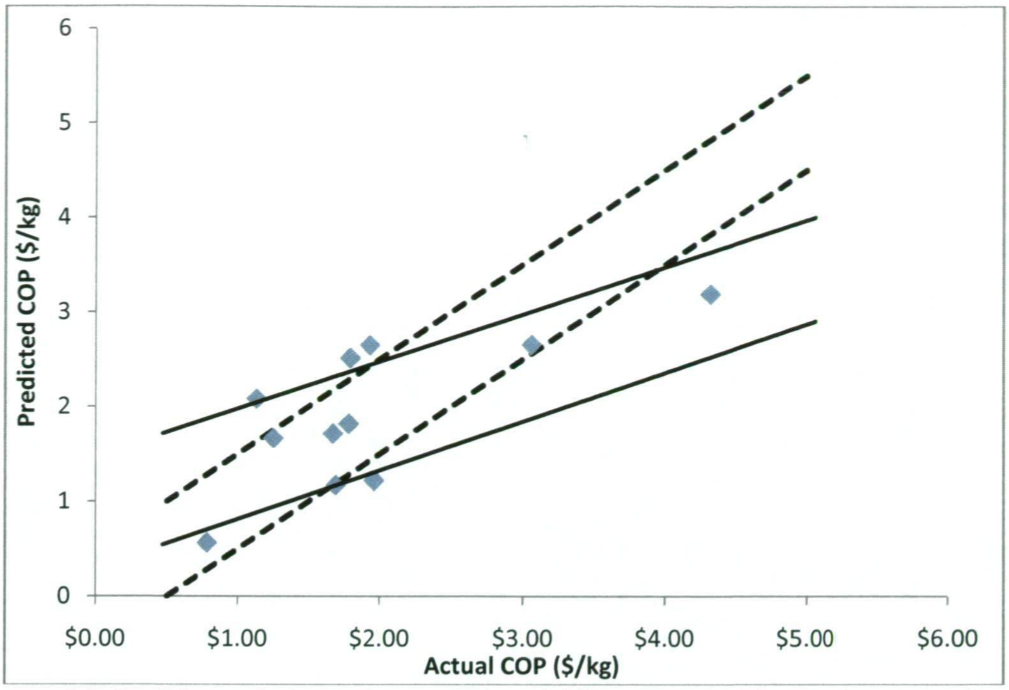

Figure 4.3 Confidence limits and accepted variability ranges with actual and predicted cost of production (per kg lwt) for 2007/2008 using the model generated from 2006/07 values. Solid line - upper and lower 95% confidence limits of the model. Dashed line – predetermined accepted variability range.

Spatial variables explained 66% of the variation in stocking rate. Enterprises characterised as having larger areas of irrigated land and higher mean annual rainfall and warmer average temperatures were positively correlated to SR (Table 4.22).

Table 4.22 Spatial model developed using 2006/07 data relating spatial variables to stocking rate (DSE/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-20.65	6.951		**
Area of irrigated land (%)	+0.21	0.041	0.21	***
Annual rainfall (longterm) (mm)	+0.014	0.0026	0.11	***
Average temperature (^{O}C)	+1.98	0.542	0.10	**

Adjusted model R^2 = 0.66, P<0.0001, ** P < 0.01, *** P < 0.001.

OP margin was related to COP, average value of beef sold, and slope (Table 4.23). This model was not able to predict OP margin for 2007/2008 within a reasonable level of accuracy. Analysis of spatial variables identified area of relatively low fertility soils, average annual temperature and area of forest and plantation as being related to OP margin (Table 4.24).

Table 4.23 General model developed using 2006/07 data relating enterprise performance and spatial variables to operating profit margin (%)for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	-0.0159	0.39211		0.9680
Cost of production ($/kg)	-0.46	0.066	0.56	***
Average value of beef sold ($/kg)	+0.646	0.2468	0.10	*
Slope (degrees)	-0.05628	0.02211	0.07	*

Adjusted model $R^2 = 0.70$, $P<0.0001$, * $P <0.05$, *** $P < 0.001$.

Table 4.24 Spatial model developed using 2006/07 data relating spatial variables to operating profit margin (%)for 27 focus farms

Variable	**Coefficient**	**Standard Error**	**Partial R^2**	**P Value**
Intercept	-2.32	0.983		0.1542
Area of relatively low fertility soils (%)	-0.012	0.0035	0.15	*
Average temperature (°C)	+0.25	0.093	0.17	**
Area of forests and plantations (%)	-7.8×10^{-3}	3.97×10^{-3}	0.10	#

Adjusted model $R^2 = 0.34$, $P = 0.005$ # $P < 0.10$, * $P <0.05$, ** $P < 0.01$.

4.3.5 Solvency

Equity% was related to average value of beef sold and the proportion of area used for forest and plantation (Table 4.25). This model was not capable of predicting equity% for 2007/2008 within a reasonable level of accepted variability.

Table 4.25 General model developed using 2006/07 data relating enterprise performance and spatial variables to equity percentage (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+0.46	0.131		***
Average value of beef sold ($)	+ 0.26	0.091	0.20	**
Area of forest and plantation (%)	$+2.4 \times 10^{-3}$	9.9×10^{-4}	0.16	*

Adjusted model $R^2 = 0.31$, $P = 0.004$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Total asset values were positively related to greater proportions of available land under irrigation for locations with greater long term annual rainfall (Table 4.26).

Table 4.26 Spatial model developed using 2006/07 data relating spatial variables to log (total assets per ha at the start of the year)* ($) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+6.29	0.416		***
Area of irrigated land (%)	+0.024	0.0067	0.31	***
Annual rainfall (longterm) (mm)	$+2.3 \times 10^{-3}$	4.5×10^{-4}	0.24	***
Area of forest and plantations (%)	-9.6×10^{-3}	0.034	0.08	*

Adjusted model $R^2 = 0.58$, $P<0.0001$, * $P < 0.05$, *** $P < 0.001$.
* Calculated using transformed data (Log(total assets/ha))

Financing costs were negatively related to equity%, area of forests and plantations, area of improved pasture, and slope, and positively related to COP (Table 4.27). This model could not reasonably predict the proportion of gross revenue used for financing costs for 2007/2008.

Table 4.27 General model developed using 2006/07 data relating enterprise performance and spatial variables to financing costs as a percentage of gross revenue (%) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+0.9	0.17		***
Equity percentage (%)	-0.526	0.1531	0.42	**
Cost of production ($/kg)	+0.078	0.158	0.11	***
Area of forest and plantations (%)	-0.005	0.1708	0.10	***
Area of improved pasture (%)	-0.0038	0.14981	0.12	**
Slope (degrees)	-0.014	0.0339	0.03	#

Adjusted model R^2 = 0.73, P<0.0001 # P < 0.10, ** P < 0.01, *** P < 0.001.

4.3.6 Expenses

Gross operating expenses per ha (GOE/ha) were greater on focus farms characterised by higher SR, lower DSE/FTE and lower equity% (Table 4.28). Properties with the spatial characteristics of higher annual rainfall and a greater proportion of land under irrigation had a greater GOE/ha (Table 4.29).

Table 4.28 General model developed using 2006/07 data relating enterprise performance and spatial variables to gross operating expenses per hectare for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+301.8	132.78		*
Stocking rate (DSE/ha)	+29.6	3.87	0.63	***
Labour efficiency (DSE/FTE)	-0.014	0.0049	0.07	**
Equity percentage (%)	-274.7	143.46	0.04	#

Adjusted model R^2 = 0.71, P<0.0001 # P < 0.10, * P <0.05, ** P < 0.01, *** P < 0.001.

Table 4.29 Spatial model developed using 2006/07 data relating spatial variables to gross operating expenses per hectare for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+51.7	122.04		0.6758
Annual rainfall (longterm) (mm)	+0.36	0.126	0.18	**
Area of irrigated land (%)	+5.7	1.99	0.21	**

Adjusted model R^2 = 0.33, P = 0.003, ** P < 0.01.

Management and staff costs, and supplementary feed costs (on a per DSE basis), were expenses negatively related to key profitability measures ROA and ROE (Table 4.30 and Table 4.31).

Table 4.30 Model developed using 2006/07 data relating return on assets (%) to expenses for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+0.09162	0.01299		***
Management and staff costs ($/DSE)	-5.27×10^{-3}	1.31×10^{-3}	0.28	***
Total supplementary feed costs ($/DSE)	-4.42×10^{-3}	1.64×10^{-3}	0.17	*

Adjusted model R^2 = 0.40, P <0.001, * P <0.05, *** P < 0.001.

Table 4.31 Model developed using 2006/07 data relating return on equity (%) to expenses for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	+0.09	0.022		***
Management and staff costs ($/DSE)	-0.012	2.2×10^{-3}	0.41	***
Total supplementary feed costs ($/DSE)	-7.86×10^{-3}	2.74×10^{-3}	0.15	**

Adjusted model R^2 = 0.52, P<0.0001, ** P < 0.01, *** P < 0.001.

Properties with a greater proportion of relatively high fertility soils were characterised by lower supplementary feeding costs per DSE (feed expenses/DSE = -0.059 x Percentage area of relatively high fertility soils + 5.63, R^2=0.37, P = 0.0004).

Properties characterised by a greater proportion of irrigated land and greater annual rainfall were related to higher total fertiliser expenses (Table 4.32).

Table 4.32 Spatial model developed using 2006/07 data relating spatial variables to total fertiliser expenses per hectare ($/ha) for 27 focus farms

Variable	Coefficient	Standard Error	Partial R^2	P Value
Intercept	-6.67	27.41		0.8099
Area of irrigated land (%)	+1.34	0.448	0.21	*
Annual rainfall (longterm) (mm)	+0.061	0.0282	0.13	**

Adjusted model R^2 = 0.34, P = 0.007, * P <0.05, ** P < 0.01.

Comparison of spatial variables identified statistical differences (P<0.05) between the area used for beef production in Tasmania and the 27 focus farm means for maximum and minimum temperatures, proportional area of improved pasture, unimproved pasture and other land uses, and the proportional area of relatively high fertility soils. For all other spatial variables, there were no significant differences between the focus farms and the wider beef producing area for the main island of Tasmania (Table 4.33).

Table 4.33 Variation of spatial attributes between the 27 focus farms and the wider beef producing area

Spatial attribute	All farms	Focus Farms
Average temperature (^{o}C)	10.9	11.1
Minimum temperature (^{o}C)	5.7	10.6*
Maximum temperature (^{o}C)	13.0	11.4*
Rainfall (mm)	963.5	830.8
Water balance	0.80	0.79
Slope (degrees)	4.94	4.00
Proportional area of irrigated land (%)	5.1	5.7
Proportional area of improved pasture (%)	58.7	72.9*
Proportional area of unimproved pasture (%)	14.5	7.2*
Proportional area of forest and plantations (%)	20.4	13.6
Proportional area of other land uses (%)	1.3	0.5*
Proportional area of relatively high fertility soils (%)	39.4	56*
Proportional area of relatively low fertility soils (%)	50.2	44

* indicates a significant difference ($P < 0.05$) between the focus farm mean and the wider beef producing area

4.4 Discussion

The purpose of this Chapter was to identify correlations between financial and environmental data relating to farm business performance and to consider the relevance of these correlates to farm productivity and business performance. Key performance indicators driving farm profitability and the extent to which the beef enterprises used represented the whole Tasmanian beef industry was also examined. Significant benefits can potentially be obtained from the analysis of enterprise performance, and the underlying landscape supporting it, for producers, industry, and policy decision makers alike. To date the amount of farm performance data collected for Tasmania has been limited and has not been readily available to the public for collation. As a consequence the results from this study should be of significant value to all stakeholders involved in beef production in Tasmania, as they provide an insight into the drivers of performance of beef enterprises in Tasmania.

4.4.1 Profitability and cost of production

ROA, ROE and OP/ha values for the 'average' beef enterprises were lower than that of the top quartile farms. ROA, ROE and OP/ha provide profitability indicators that account for differences in asset value, level of equity, and property size respectively. Top quartile beef enterprises had a COP that was 35% lower than the average beef enterprise, with COP negatively associated with all these profitability measures. Holmes *et al.* (2008) identified COP as having the greatest influence on farm profitability. The current analysis showed COP accounted for nearly 40% and 23% of the variation in ROA and ROE respectively and 51% and 56% of the variability in OP/ha and OP margin respectively.

COP is used as a measurement of both efficiency and risk and is widely regarded as a significant KPI for many enterprises (Johnstone 1999; Newman & Chapman 2001; McEachern *et al.* 2005; Holmes *et al.* 2008). The negative relationship observed between profitability and COP has been reported previously (Newman & Chapman 2001; McEachern *et al.* 2005; Giumelli 2006; Holmes *et al.* 2008) with a lower COP an indication of greater efficiency and a reduced enterprise risk profile. Changes in COP are an important indicator of the likely effect on profitability associated with changes to the level of production (Holmes *et al.* 2008). COP can be used to determine the minimum required price received per unit of output to ensure a business remains profitable. A lower COP minimises the impact from reduced revenue and increased expenses.

While spatial attributes of focus farms were not significantly correlated to COP, almost 35% of the variation in COP was accounted for by beef productivity within the enterprise. Given the negative relationship existing between these factors, one strategy available to producers to manage COP would be to improve beef productivity per unit of land area. The relationship between COP and production per ha was consistent with Holmes *et al.* (2008), who reported that increasing the level of production per ha had greater potential for decreasing COP compared to enterprises attempting to reduce operating expenses.

A smaller amount of the variability in COP was related to EBA and DSE/FTE (9.2 and 6.6% respectively). Previous findings into the impact of farm size on financial performance have also been inconclusive (Purdy *et al.* 1997). The relationship between EBA and COP implies that economies of scale apply to COP, with larger enterprises being able to distribute some of their production costs more efficiently and therefore improve profitability through a reduction in expenditure per unit output (Purdy *et al.* 1997).

The model developed for COP was not capable of predicting COP for subsequent years, however the proximity of the 95% confidence limits and the accepted variation indicate that with a larger dataset and further development the model is likely to be suitable as a general guide for industry. The lack of predictive ability of the developed COP model, as well as the model's modest adjusted R^2 value (0.44), indicate that there were other significant influencing factors not accounted for in the model. These may include seasonal weather variation, farm management decisions and other practices not covered by this study. A more in-depth investigation assessing detailed management practices over multiple seasons may provide further insight.

The OP margin indicates the proportion of gross revenue that is retained as profit, and is used as a measure of both profitability and risk. OP margin is an important performance benchmark as no profit driver is ignored in its calculation (Holmes *et al.* 2008). There was a substantial range of OP margins, and a large numerical difference between the average and top quartile farms. The strong relationship (R^2 = 0.56) recorded between OP margin and COP, and the fact that both indicate the risk exposure of an enterprise, supports the finding that controlling COP is important for increasing profitability and reducing risk (Holmes *et al.* 2008).

Pasture production and utilisation are regarded as fundamental components of any grazing production system. Soil fertility, average temperature, and the area of different land uses and vegetation coverage are known to influence pasture production (Pearson & Ison 1987). The inclusion of these variables in the spatial models for ROA, ROE, and OP margin indicated that focus farms that have a greater potential for pasture production could be expected to have a greater potential profitability if the additional pasture capacity is utilised. This increased profitability is as a result of increased productivity as well as reduced expenses, such as supplementary feeding, that can be achieved.

4.4.2 Productivity and efficiency

Productivity and efficiency were also identified as playing a significant role in enterprise profitability, through the inclusion of measures such as average lwt of beef sold and beef production/ha into the models developed for OP/ha, change in equity and (when capital gains were included) ROA and ROE. Average lwt sold was also incorporated into the model for total lwt produced per ha, and total lwt sold per DSE was related to kg/ha/100mm. Improvements in efficiency and productivity are regarded as the key areas for greatest potential improvements in profitability (Newman & Chapman 2001; Holmes *et al.* 2008).

Productivity

Properties producing a heavier average lwt of livestock at sale, operating at a greater SR and with a higher average slope had a greater level of lwt production per ha. Production per ha and the quantity of beef sold per ha were strongly correlated to soil fertility. This is demonstrated by the inclusion of proportional area of low fertility soils and fertiliser expenses per ha into the spatial model for production per ha and the general model for beef sold per ha. Given the relationship soil fertility has with pasture production (Pearson & Ison 1987; Hopkins 2000; Parsons & Chapman 2000), increased pasture production, when utilised, leads to greater potential productivity per ha through both increased carrying capacity and greater potential individual lwt gain.

The area of improved pasture was negatively related to beef sold per ha and beef sold per DSE when only the spatial variables were analysed. This is in contrast to previous findings where the area of improved pasture has been positively correlated to increased productivity (Archer & Robinson 1988; Robinson & Archer 1988; Lodge 1994; Lodge *et al.* 1998). When the area of improved pasture was removed from the analysis water availability, (rainfall and area of irrigation) were positively related to beef sold per ha whilst the area of relatively low fertility soil was the only variable included in the model. During the 2006/2007 financial year, many regions of Australia, including parts of Tasmania, suffered severe drought conditions that reduced farm production. Producers sold stock in response to a reduction in pasture availability and an increase in feed grain and fodder costs (ABARE 2007, 2008b). Survey results found that many producers sold a greater proportion of unfinished or younger animals (ABARE 2008b). Although focus farms with a greater area of improved pasture may have been able to maintain a greater carrying capacity then those focus farms with less area of improved pasture, they may have destocked at a greater level or retained a greater proportion of stock thus influencing the production results. Survey results for 2007/2008 indicate many producers were still under pressure from drought conditions (ABARE 2009b). Improved seasonal conditions following dry periods result in a reduction of cattle sales as producers retain livestock in order to rebuild cattle numbers. An analysis of individual enterprises over multiple seasons would be required to determine if changes to stocking rates and cattle movements had a significant influence on the results.

Stocking rate

SR was closely related to both productivity (beef/ha) and profitability (ROE_{CG}), and has been shown in previous research to be driven largely by pasture production potential and hence carrying capacity of the land (SheepCRC 2007). Using the decision support tool GrassGro, Donelly *et al.* (1998) found that profitability increased with increased SR up to a point, beyond which further increases in SR had only a marginal impact on profits. Factors such as soil fertility and water availability that influence pasture production, and therefore carrying capacity, have previously been found to affect SR (Nicol 1987; Pearson & Ison 1987; SheepCRC 2007).

Pasture production is a strong driver of potential SR, with SR the largest driver of pasture utilisation (SheepCRC 2007). Increased pasture utilisation is a very effective means of increasing profitability and productivity, however achieving greater levels of utilisation are associated with range of different risks, such as poor pasture persistence, exposure of soil surface and more drought management issues (SheepCRC 2007). Spatial variables identified as being significantly correlated to SR were all related to pasture production, thus supporting previous findings of the inherent relationship between pasture production and SR. This relationship could be further described by the collection of on-farm data relating to pasture growth patterns and pasture quality. Producers with a greater understanding of their pasture production profile and carrying capacity can maximise production and profitability through optimising SR across the year.

Based on the industry-wide spatial data (presented in Chapter 3), the potential SR predicted from the spatial model developed was 14.5 DSE/ha. This result was similar to the average for the focus farms. Based on a total area of 748,607 ha for the industry this would equate to 10.8 million DSE. Using the assumption that one cow is equivalent to 14 DSE (Holmes *et al.* 2008) the model predicts that the total Tasmanian herd size would be equivalent to 775,343 breeders. This figure is considerably greater than the actual cattle number for Tasmania of 501,000 in 2006 (ABARE 2007). The difference between the calculated potential state herd numbers and actual population may be because of the influence of the 1/3 of SR variation not accounted for by the model, and because the total area for beef production also incorporates land used for other enterprises on mixed enterprise properties. Further analysis of the proportion of this land that is used for other enterprises would indicate any potential improve the capacity to predict potential increases to SR.

Efficiency

Core per ha costs and core per DSE costs are an indication of production efficiency. Efficiency improvements can be achieved by either increasing output for the same or reduced inputs, or through increased inputs for a proportionally greater lift in outputs. The top quartile ROC enterprises had a decreased core per DSE cost but a greater core per ha cost than the average farms. This relates to the more profitable farms having a greater level of productivity per ha, so although the more profitable farms had higher input costs their output was disproportionately higher. The positive relationship between core per DSE costs and water balance may be attributed to the relationship between increased fertiliser expenses on focus farms with greater water availability. In comparison the decreased core per DSE costs associated with increased area of improved pasture is conceivably the result of increased pasture production, and therefore either increased SR or reduced supplementary feeding costs. While only accounting for 14% of variation in core per DSE costs, focus farms that have a greater equity% had a reduced core per DSE costs. The positive relationship between core per ha costs and SR and with productivity (kg/ha/100mm) highlights the importance of striking the right balance between costs per ha and production per ha to maintain or improve profitability. The relationship between core per ha costs and area of irrigated land appears to be a result of the relationship increased fertiliser expenses had with both area of irrigated land and long term rainfall .

Improvements in labour efficiency are known to have a strong impact on profitability. However, there is an important balance between labour efficiency and labour costs (Holmes *et al.* 2008). The benefits of high labour efficiency are reduced if the associated costs disproportionately increase the COP. In contrast, reducing labour costs at the expense of efficiency can also reduce profitability. The average enterprises had a DSE/FTE of 6,653; this is notably less than the average for 2007 of 10,174 DSE/FTE from Holmes *et al.* (2007). The data presented by Holmes *et al.* (2007) were combined for Tasmania, Victoria, New South Wales and South Australia. Hence, no data specific to Tasmania were available for direct comparison. Based on the results of Holmes *et al.* (2007) there is potential to further improve enterprise performance in Tasmania through labour efficiency improvements.

The management and staff costs for the average focus farm group were $1/DSE less than the top quartile farms but ranged from as low as $2.05/DSE up to $21.31/DSE. The combination of a lower DSE/FTE and a wide range of management and staff costs/DSE implied that there is potential for some enterprises to make significant improvements in reducing their labour costs and increasing efficiency. Staff and management costs were greater on focus farms with lower maximum temperature, greater area of low fertility soils, and a greater estimated water balance. The reasons for this relationship may be either related to the lower potential pasture production requiring increased supplementary feeding. Alternatively, another possible explanation is having a lower carrying capacity leading to a lower SR and therefore reduced total DSE managed leading to less efficient use of labour resources. The spatial models developed for DSE/FTE, and management and staff costs per DSE accounted for only 12 and 33% of variation respectively. The poor relationship between spatial variables and labour efficiency indicate other factors that were not measured, (e.g. management practices), have a stronger relationship with labour efficiency. Further research evaluating the management philosophy and practices of beef enterprises would enable greater understanding of the drivers of labour costs and efficiency, and thus an indication of where improvements in labour efficiency can be made.

4.4.3 Solvency

Solvency refers to the confidence in meeting debt obligations and can be measured using equity%, total assets per ha, and financing costs%GR. The value of both land and livestock are drivers of equity% as they influence the enterprises asset value. The developed model for equity% identified average value of beef sold and area of forest and plantation as being the only significantly related variables; this supports the influence that value of livestock has on equity% and indicates that different land uses can influence equity%. As this model had a low R^2 further analysis using a larger or independent data set would be beneficial.

The total assets per ha indicate the amount of money that could be generated from the sale of all assets. When this value is compared to total liabilities it indicates the level of solvency of a business. The area of irrigated land and the long term rainfall of focus farms were related to 58% of the variation in log(total assets per ha), indicating that the more valuable properties had a greater average rainfall and more area under irrigation. This relationship could be as a result of greater SR and hence livestock valuation on focus farms with more water availability (as highlighted in the model developed for SR), a reflection of the market value for properties in higher rainfall zones, or related to irrigation equipment increasing the value of assets. As there was no breakdown in asset value that was specific to land value (exclusive of buildings) and irrigation equipment it was not possible to test this hypothesis.

The proportion of gross revenue that was used for financing costs was greater on focus farms that had lesser equity%, greater COP, reduced area of forests and plantations, reduced area of improved pasture, and a lower average slope. Given the relationships equity% and COP have with risk, this relationship implies that the level of risk and the proportion of different land uses are strong determinants of financing costs. The relationship that different land uses have with financing costs is likely to be a result of the amount of capital required for the purchase of different land types. Despite the high R^2 value of the model it was not capable of predicting the financing costs for the 2007/08 year. Factors, such as fluctuating interest rates and seasonal weather conditions, are significant variables influencing annual financing costs. In order to develop a model that is capable of predicting future financing costs an indication of factors such as interest rates would be required with records spanning a number of seasons.

4.4.4 Expenses

Beef and other commodity producers are generally regarded as 'price takers' rather than 'price setters'. The price received per kilogram for beef produced in Tasmania is strongly influenced by international markets (Bindon & Jones 2001) and so, as a result, producers generally have greater control over the level of productivity and costs associated with production rather than the product prices received. Stocking rate accounted for 63% of variability in GOE/ha, whilst a decreased DSE/FTE and equity% was related to a further 10% of variability. Given the positive relationship of SR to productivity which is positively related to profitability, there is an important balance between increasing SR and its associated costs, which will negatively influence profitability. This was highlighted previously when analysing COP. Establishing the optimal balance between increased productivity and the associated costs of achieving it in individual enterprises can be greatly enhanced through the use of benchmarking activities which produce a concise breakdown of production costs, profitability and productivity. The association of increased GOE/ha with increased area of irrigated land and long-term rainfall could be explained, potentially, as a result of the costs associated with irrigation or the increased level of fertiliser application on focus farms with more irrigated land and higher long-term rainfall.

Management and staff costs per DSE (as previously discussed) and the total supplementary feed costs per DSE were significantly correlated to the profitability measures ROA and ROE. The cost of feed and supplements per DSE for the average farms was more than double that of the top quartile producers. Although supplementary feeding can increase production it is a more expensive energy source than pasture harvested by grazing. Therefore, increased levels of supplementary feeding can reduce profitability. Those focus farms with a lesser area of relatively high fertility soils had increased feed and supplement expenses. The amount of feed required to meet livestock demands for maintenance and production, and therefore the associated costs, is largely driven by the prevailing feed deficit. Stocking rate and pasture production are key determinates of feed demand and utilisation (Graham *et al.* 2003; SheepCRC 2007). Properties with a larger area of relatively high fertility soils were more likely to have a greater potential pasture production and therefore reduced supplementary feed requirements. Matching available feed supply to livestock demand are a proven method of reducing supplementary feed costs and hence profitability.

4.4.5 Spatial attributes

Soil fertility, longterm rainfall and water balance, proportion of different land uses, and temperature were all incorporated into multiple models for productivity and efficiency, profitability, and risk. The relationship that different land uses had with profitability, productivity, efficiency and solvency can be attributed to the influence different types of land use have on pasture production and land value.

Increased area of irrigated land was correlated to greater SR and total assets, but also with greater GOE/ha, and core per ha costs. Similarly longterm rainfall was incorporated into models for SR, average lwt sold, total assets, GOE/ha, fertiliser expenses/ha, and core per ha costs. These results indicate that increased water application (from rainfall and irrigation) are related to increased carrying capacity but also with increased costs. Striking the right balance between productivity and costs is necessary to ensure profitability and sustainability is maintained (Holmes *et al.* 2008)

The developed models indicate that the increased proportion of relatively low fertility soils are correlated with decreased productivity and profitability. It is not possible to alter the soil types present on a farm. However, when considering land suitable for beef production the importance of soil fertility on potential productivity and profitability is demonstrated by the inclusion of (relative) soil fertility in many of the developed models. Given the relationship between soil fertility and enterprise performance, the use of tools such as soil tests and soil fertility assays may be valuable for producers to further improve productivity and profitability through maximising the production potential of the land.

The relationships identified between productivity and profitability measures, and COP and SR, as well as the relationship between spatial variables and SR with productivity highlight the influence that the landscapes supporting the enterprises have on productivity and profitability. The magnitude of these effects varies for different productivity and profitability measures. The proportion of relatively low fertility soils had the greatest impact on productivity. With all other variables remaining equal an increase of 5% in the proportional area of relatively low fertility soils would decrease lwt production per ha and lwt sold per DSE by 15.3 and 0.85 kg respectively. An increase in temperature would have the greatest affect on enterprise profitability (ROA and ROE) and SR. a $1^{0}C$ rise in temperature is expected to raise ROA by 1.67% and ROE by 2.5%. The same temperature rise could increase SR by 1.98 DSE/ha. Given the intimate interaction that climatic variables such as temperature and rainfall have, an increase in temperature would be expected to be accompanied with variation in all other climate factors.

Temperature, rainfall, soil fertility and proportional area of different land uses were included in multiple models. All of these variables are known to be strong drivers of pasture production (Pearson & Ison 1987; Parsons & Chapman 2000) and, therefore, potential carrying capacity and productivity per unit area of land. Increased pasture production can improve profitability through both greater productivity and reduced costs, such as supplementary feeds.

4.4.6 Assessment methods

The semi-quantitative method used for testing the ability for the model to predict results for 2007/2008 involved both paired two-sample t tests and the use of confidence limits and accepted variability. Some of these models produced predicted results that were not significantly different to the actual results. However, when the models were further analysed using the confidence limits and accepted variation they were found to be unable to predict results for 2007/2008 with acceptable precision. Still, given the proximity of the confidence limits and the accepted variability range and the location of the data points, these models could be used as a general guide at a wider industry level with more development. The inability of the developed models to accurately predict the 2007/2008 results imply variation that is not accounted for by any of the included measured variables. A broader data set may improve the predictions of the models. The use of a larger independent data set to test the models ability to predict results would be beneficial.

Variables such as pasture production, seasonal conditions (e.g. long term average rainfall and temperatures for individual months), and more detailed information relating to management practices and attitudes would be beneficial in developing stronger models for productivity and profitability that are able to predict results for subsequent years with sufficient accuracy. The key to this outcome is securing greater participation of farmers in this type of research. Increased participation rates could be achieved through greater awareness of the benefits of benchmarking exercises and by encouraging the development of a culture of continuous improvement. During this study the use of field days and discussion groups demonstrated the benefits that can be obtained from direct communication with producer groups.

There is some variation between the spatial attributes for all beef farms in Tasmania and the focus farms, however, these values are still comparable. A larger data set would potentially allow the spatial data to be separated into regional areas (e.g. North, South and North-West). This regional segregation may further improve how closely the focus farms represent the industry. However, despite the limited data set it can be concluded that the 27 focus farms used in this study adequately represent the beef industry as a whole

4.4.7 Conclusions

The integration of spatial and financial information used in this project proved successful in identifying and evaluating the relationships between profitability measures, productivity, and spatial variables. Many of the findings from this research were consistent with previous findings for key profitability and production drivers. This indicates that GIS and financial benchmarking can be effective tools to help quantitively analyse farm performance and the key drivers of production and profitability.

5. Relationships between financial and environmental data on farm business performance at a beef enterprise level in Tasmania

5.1 Introduction

The natural resources and ecosystem services of agricultural landscapes underpin the potential productive capacity of farming enterprises and, as a consequence, their potential profitability and economic viability. In Chapter 4, the significance of natural resources to farm business performance in the beef industry in Tasmania was demonstrated by the correlations that various biophysical variables have with production and profitability outcomes. Knowledge of these inter-relationships and the significance of environmental stewardship to farm business performance can be used to improve on-farm best practice and support industry development (Bateman *et al.* 1999).

Natural resource management is now recognised as an important aspect of farm management. In 2006/2007, 94.3% of Australian agricultural businesses reported undertaking natural resource management activities and dealing with issues such as pests, weeds, and land and soil degradation (ABS 2008) At the time, the total investment in these activities in Australian agricultural landscapes was in the order of $3 billion.

There is a range of options available to farmers to address natural resource management issues. The management practices undertaken by producers may be tailored to the needs of individual farms and influenced by available resources, farmer experience and attitudes, and socio-economic factors such as the family situation (Gillespie *et al.* 2008). The environmental decisions made and practices implemented by farmers may influence the sustainability of the farm enterprise and its productivity and profitability in the short term and long term (Oliver *et al.* 2009).

In this Chapter case studies were used to investigate relationships between financial and environmental data and farm business performance at a beef enterprise level. The aims of the Chapter were to:

- Evaluate the application of developed industry level farm business performance relationships at an enterprise level
- Investigate the relationships between natural resource management practices and farm business performance.

5.2 Methods

From the industry-level study (Chapter 4), four properties were selected as case studies based on a combination of their size, profitability and productive performance, and geographical location. The properties were selected to enable comparison of these factors. Farms 1 and 2 were located in the north-west region of Tasmania, while Farms 3 and 4 were located in the Meander Valley (approximately 15 km south-west of Launceston). Data from the benchmarking process were used to identify enterprises at each location that differed in their size, profitability and performance.

The owners of each of these properties were interviewed using the same series of questions. The survey used was developed based on standard ABARE and NRM surveys (Mitchell *et al.* 2007; ABARE 2009b). Questions addressed natural resource and environmental management, environmental problems, management philosophy, and risk management. The questions were intentionally open-ended to ensure that information was collected in a non-directed manner, and enabled the interviewees to provide their answers in their own words. It took on average 90 minutes to complete each survey. Participants were allowed to make comments additional to the survey.

The survey questions were:

1. What are the most important natural resources or environmental assets on your property?
2. Are these environmental assets important to farm production and profitability?
3. What environmental assets are most important to your farm production?
4. On a scale of 1 to 10 with 1 being not important and 10 being very important, how would you rank the importance of environmental assets on your property?
5. How do you manage the environmental assets on your property?
6. Do you rate the management of your environmental assets as important as livestock management?
7. On a scale of 1 to 10 with 1 being not important and 10 being very important, how would you rank the importance of management of environmental assets on your property?
8. Do you have environmental management issues such as pests, weeds, and land and soil problems?
9. What are the most important environmental management issues?
10. Do these issues affect farm production and profitability?
11. On a scale of 1 to 10 with 1 being no impact and 10 being maximum impact, how would you rank the affect these issues have on farm production and profitability?
12. Do you have access to sufficient information and support to manage the environmental assets and problems on your property?
13. How would you describe your management philosophy?
14. Is risk management a part of your management approach?
15. What factors do you feel are important to management that are beyond your control?

16. On a scale of 1 to 10 with 1 being no impact and 10 being maximum impact, how would you rank the impact of these factors to farm production and profitability?

Survey results were then used in conjunction with previously collected spatial and financial data to compare and contrast the four farms. Using the data collected in Chapter 4 it was possible to determine if a case study enterprise was significantly different from the mean of the 27 focus farms for each of the variables. This was performed using the t-test function of SAS/STAT software (Version 9.1, 2002-2003, SAS Institute Inc., Cary, NC, USA). A one-sample t-test was used to determine if there was a significant ($P>0.05$) difference between the mean of the focus farms and each of the case study farms. This was performed for a range of key profitability and productivity values. The upper and lower 95% confidence limits for the mean are presented on the graphs.

The models developed in Chapter 4 were applied to each of the case study enterprises to determine their effectiveness for application at an individual enterprise level. Values for key productivity and profitability variables were calculated using the 2006/2007 data set. It was not possible to determine if the difference between the predicted and actual values were statistically significant, so differences greater than the accepted variability (as assigned in Chapter 4, Table 4.1) were regarded as being of practical importance.

5.3 Results

5.3.1 Case study descriptions

The four case studies exhibited a range of spatial and financial attributes. A summary of each farm is presented in Table 5.1. The proportional area of different soil types present on each of the focus farms are illustrated in Figure 5.1.

Table 5.1 Profitability, productivity and spatial variables for each of the case study farms and the focus farm mean.

Variable	Farm 1	Farm 2	Farm 3	Farm 4	Mean (focus farms)[1]
Effective beef area (ha)	50	490	144	873.5	437.7
Total DSE	1,305	9,397	2,067	12,268	5975.5
Stocking rate (DSE/FTE)	26.1	19.2	14.4	14	15.5
Long term annual Rainfall (mm)	1250	930	832	778	830.8
Longterm Average Temperature (^{o}C)	11.2	12.2	10.6	10.8	11.1
Water balance	0.85	0.78	0.76	0.74	0.79
Slope(^{o})	8.9	0.97	1.63	3.25	4.00
Area of relatively high fertility soils (%)	73.5	44.4	63.9	66.9	56.22
Area of relatively low fertility soils (%)	26.5	55.6	36.1	33.1	43.23
Area of irrigated land (%)	0	0.08	15.44	4.24	5.75
Area of improved pasture (%)	0	99.92	65.43	87.70	72.89
Area of unimproved pasture (%)	0.11	0	18.13	7.59	7.23
Area of forest and plantations (%)	99.89	0	0	0.29	13.79
Area of other land uses (%)	0	0	1.00	0.18	0.34
Return on assets (%)	-1.30	1.10	-1.40	-1.70	-0.19
Return on assets (including capital gain) (%)	10.40	15.50	-2.10	1.70	9.56
Return on equity (%)	-1.30	1.10	-2.50	-3.70	-2.03
Return on equity (including capital gains) (%)	10.40	15.50	-3.30	0.40	9.78
Operating profit ($)	-10,935	51,964	-25,423	-74,719	17,417
Operating profit per ha ($/ha)	-219.00	106.00	-177.00	-86.00	32.89
Operating profit margin (%)	-32.0	20.9	-106.1	-52.2	-16.9
Equity (%)	100.00	100.00	88.60	81.30	85.67
Total assets per ha ($)	11,336	8,369	8,878	4,872	6,264
Change in equity ($)	98,500	667,450	-10,794	129,681	251,615
Cost of production per kg (liveweight) meat ($/kg)	1.56	0.99	2.98	1.69	1.80
Core per DSE costs ($/DSE)	9.99	3.51	4.36	5.27	6.47
Core per ha costs ($/ha)	319.00	169.00	130.00	74.00	163.85
DSE per full time staff equivalent (DSE/FTE)	4,350	6,712	5,663	14,021	7585
Management and staff costs per DSE ($/DSE)	11.49	7.39	10.28	3.91	8.10
Financing costs as a percentage of gross revenue (%)	0.4	0.6	62.9	44.2	19.6
Total liveweight of beef produced per ha (kg/ha)	577	404	115	148	300
Total liveweight of beef sold per ha (kg/ha)	1,017	382	140	184	382
Total liveweight of beef sold per DSE ($/DSE)	39	19.9	9.7	13.1	22.97
Average beef value per kg (liveweight) ($/kg)	1.20	1.15	1.38	1.21	1.40
Average liveweight of beef sold (kg)	450	520	353.1	400	434.9
Feeds/Supplements expenses per DSE ($/DSE)	0.84	1.22	0.19	3.33	2.28
Fertiliser expenses per ha ($/ha)	86	61	55	14	57
Weed and pest control expenses per ha ($/ha)	0	3	9	6	2

[1]n=27

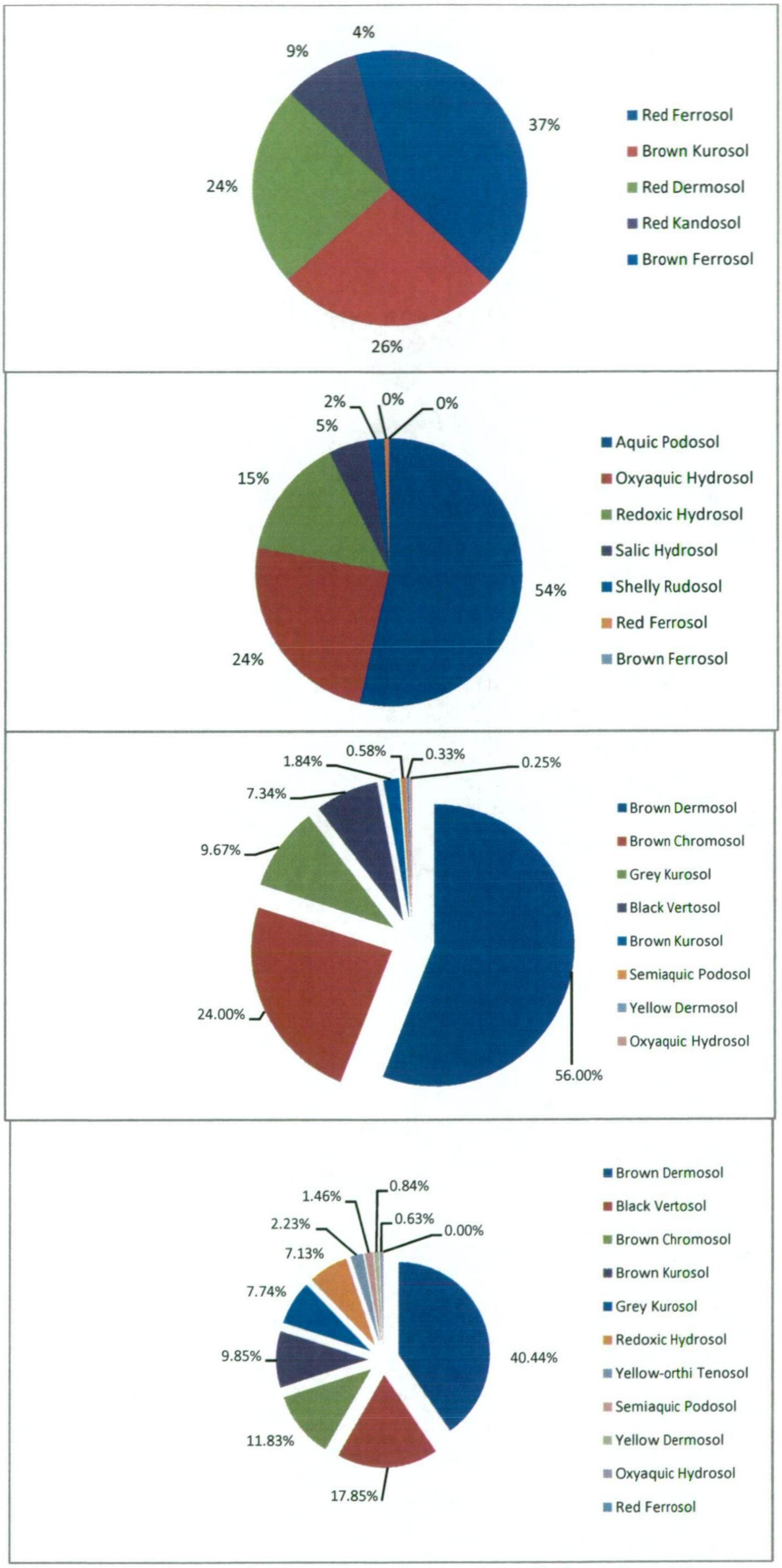

Figure 5.1 Proportional area of soil types on Farm 1, Farm 2, Farm 3 and Farm 4

Farm 1 was a 76 ha property on the north-west coast of Tasmania run solely as a beef cattle enterprise. On this property cattle trading was the focus. Weaners were purchased and grown to sell as finished yearlings. A small amount of cattle breeding also carried out. The soils were generally highly fertile; the three dominant soils on the property were red ferrosol, brown kurosol and red dermosol (Figure 5.1).Land use data indicated a large proportion of the land covered in native vegetation, made up of remnant native cover and trees planted for shelterbelts (Table 5.1).

Farm 2 was a 490 ha beef property located on the North-West coast primarily selling finished steers to processors. All of the land supported improved pasture. Just over half the soils on the property were aquic podosols with various hydrosol sub-orders making up most of the remainder (Figure 5.1).

Farm 3 was a 588 ha property in the Meander Valley involving a 'self-replacing' beef cattle herd as well as wool and cropping enterprises. A large proportion (56%) of the property was on brown dermosol soils. Brown chromosol, grey kurosol and black vertosol soils accounted for the majority of the remaining area (Figure 5.1). Approximately 65% of the total land area supported improved pasture.

Farm 4 was an 1815 ha property located in the Meander Valley involving a combination of beef and wool production enterprises. The beef enterprise was a breeding enterprise that involved selling yearling cattle. The property consisted of a number of different soil types. Three soils covered the largest area - brown dermosol, black vertosol and brown chromosol (Figure 5.1). The majority of the land supported improved pasture.

5.3.2 Biophysical comparisons between case studies

All four case studies had similar estimated water balances with Farm 1 having the highest value. The estimated water balances for the case study farms were comparable to the average for Tasmanian beef farms (Figure 5.2). Farm 1 had a higher long term average rainfall than the other case study enterprises. The combination of a greater water balance and higher rainfall indicated greater (overall) water availability for Farms on the NW coast compared to Farms in the Meander Valley. All four case study properties had lower mean slope values compared to the State average with Farm 2 and Farm 3 having the lowest values. Farm 2 had a higher mean annual temperature than the State average, although all the case study enterprises are within 0.5°C of the average for all beef farms in Tasmania (see Chapter 3). Farms on the NW coast had a slightly higher mean annual temperature than farms in the Meander Valley (Figure 5.2).

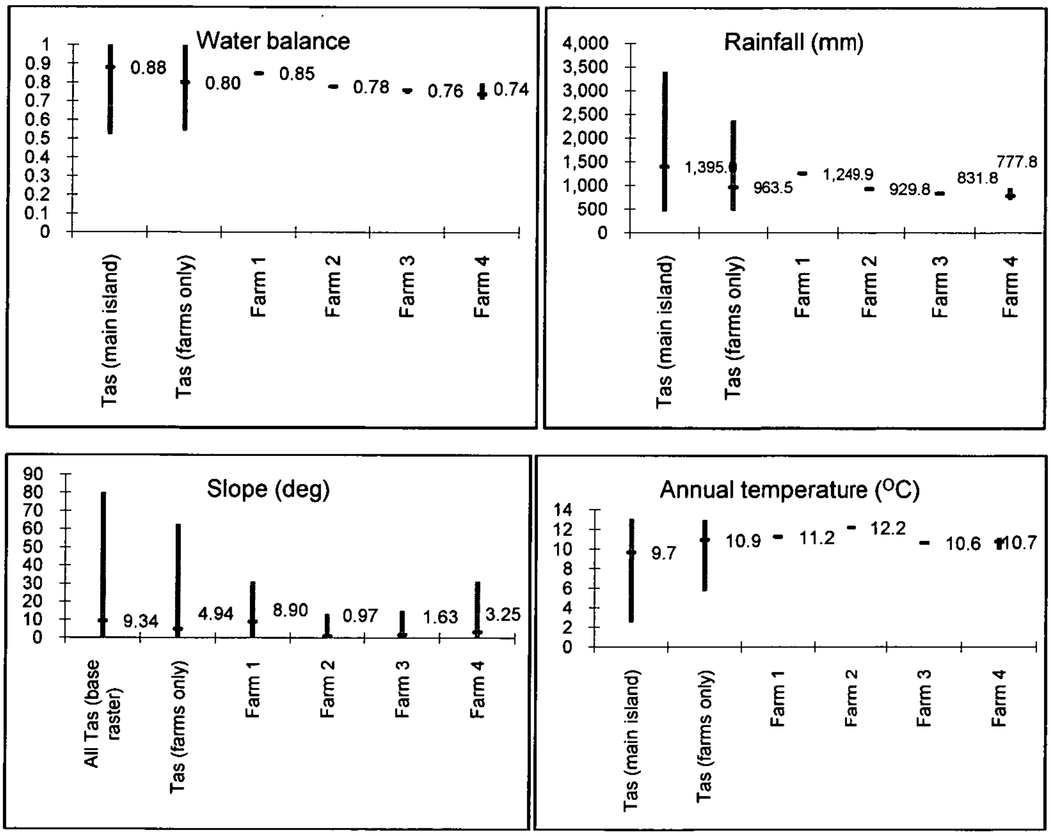

Figure 5.2 Range in estimated water balance (relative index 0-1), longterm rainfall (mm), slope (degrees), and mean annual temperature (°C) ranges for the four case study farms compared to Tasmanian beef farms and the Tasmanian environmental range. Horizontal bars indicate the average values.

The smallest of the four case study enterprises, Farm 1 had a much greater stocking rate, and therefore lwt produced per hectare, than Farm 2, Farm 3 and Farm 4. The enterprises on the NW coast had a lesser cost of production per kg beef than enterprises in the Meander Valley and the focus farm average. However, the GOE/ha and core cost per DSE were both greater for Farm 1 than the other three case studies and the focus farm average (Figure 5.3). Farm 1 was the only case study that had an expense for weed and pest control that was lower than the average. Farm 2 showed a higher profitability than all other case studies and the focus farm average.

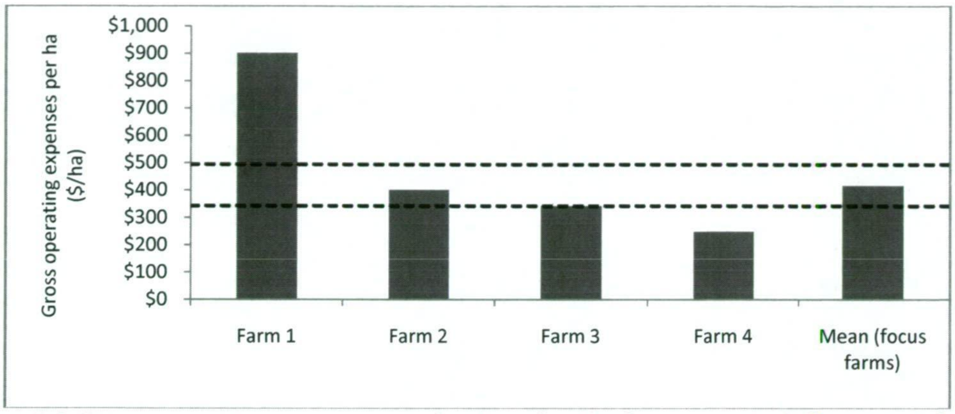

Figure 5.3 Gross operating expenses per hectare for the four case study farms and focus farm mean

5.3.3 Survey

There were many similarities in the survey responses obtained from each of the case study enterprises. Shelterbelts, water resources and soil were the variables most commonly identified as being the most important environmental assets (Table 5.2). Weeds and pests were identified as important environmental issues. The practices implemented to manage these assets and issues were similar for all four case study farms. The importance of environmental issues for enterprise productivity and profitability were identified as a result of their impact on pasture production, and the costs required for weed and pest control. All of the case study farms regarded risk management as a component of their management strategy.

Table 5.2 Summary of survey results for 4 case study farms.

Question	Farm 1	Farm 2	Farm 3	Farm 4
1	Shelter belts On farm water storage	Rainfall Fertility Location, coastal location affects temperature and decreases frost risk	Water Timber and shelter belts Soil	Soil Water Shelter
2	Yes	Yes	Essential	Yes
3	Trees Soil	Rainfall Fertility Location	Climate and the seasons	Rainfall Soil fertility for production Have to recognise the stocking rate and carrying capacity for the area and the specific year
4	10	10	10	10
5	Fencing around shelter belts and dams	Regular soil testing and replacement of lost nutrients Destocks when pasture production is reduced	Fencing around shelter belts Drainage lines to increase dam catchment Maintain cover on soil Soil tests for crops	Ensuring vegetation cover on soils Fencing to graze certain areas at certain times, certain paddocks need to be treated differently Stock water can be a limiting factor in paddock design and sub-division
6	Yes. Considers it a personal choice to look after the environment	Environmental management is more important, livestock is simply a means of turning grass into money	Livestock come first, everything is done with livestock in mind	Environment is more important then livestock, if you get the environment right the livestock is easier and better Need to find a balance with the available financial resources
7	10	10	Environmental assets generally take care of themselves now, most things are lower priority because they are not urgent. Issues are addressed if they are urgent. Other then selective logging operations the environmental assets are not directly money generating.	10
8	Yes. Weeds, in particular broadleaf flat weeds, thistles and blackberries	Weeds are the biggest problem, a nearby state reserve acts as a seed bank for weeds	Wallabies, brushtail possums, and crows Gorse, thistles, blackberries, cape weed, and willows	Yes. Have to be aware of erosion risks. Weeds and pasture pests are a problem
9	Weed control Maintaining water quality and availability	Weeds, hemlock is a significant problem as it is toxic to stock. Thistles, blackberries and boxthorn also need to be kept under control	Gorse, takes up ground space and provides habitat for wallabies	Weeds: gorse, hawthorns, blackberries and thistles Corbies and cockchafers
10	No because they are kept under control, otherwise they would	Yes, everything that has to be managed costs money	Definitely	Yes. Weeds effect profit more in the cost to remove them, short term production is not as strongly affected whereas insect

				pests and browsing animals affect production significantly
11	2-3	Weeds: 2-3 provided they are kept under control	Gorse has a maximum impact (10) on the ground it's on and the surrounding area due to wallabies. Greater impact in years when feed is short	Weeds: 7 Pests: 9
12	Yes, but you have to go out and find it. Have learnt a lot themselves	Yes. Some information is easy to find but some requires more searching	Never enough funding available. Fencing that needed to be done around shelter belts and remnant vegetation and water sources was able to be done sooner through funding	Yes, but there is not enough financial support. It is frustrating that more on-ground money can't be pushed towards weed control roadside weeds are a big problem and more needs to be done by local and state government to manage weeds. Have had some funding and/or assistance for: fencing, creek bed willow removal, river health and flood erosion management, and vegetation to plant within fenced areas
13	Considers their management philosophy to be good but acknowledges that there is no comparison tool. Base many of their management practices on dairy farms. Focused on avoiding chasing on what they regard as never ending problems. For example controls weeds rather than trying to eradicate them completely	Keep it simple Be there everyday Keep expenses down Pay debt off Take holidays Manage enterprise to make the most of resources Regard themselves as grass farmers rather than livestock farmers	Do it because they love it	Try to be low impact natural manager rather than high input. Lower input leads to lower returns per ha but hopes that it is in balance with longer term sustainability Try to be conscious of the environment A lot more focussed on livestock farming rather than cropping
14	Yes. Minimises risk through only paying a certain amount for certain sized cattle. Calculates expected profits based on a lower received price.	Looks at both farm risk and financial risk. Has made mistakes and learnt from them, been conservative and intelligent. Enterprise gets finetuned rather than radically changed. Produce the heaviest weight to get the greatest return. Work with buyers and help to form alliances with other companies	Yes. Mixed enterprises spread the risk. Each year reviews their operations and any new enterprises or crops are assessed. Risk management assessment is especially important when changing any enterprises.	Run both sheep and cattle. Is always conscious of risks, used Wool Futures in the past and would hold back if the price was too low Try to maintain a storage of hay
15	Weather Rising input prices Cattle prices	Rainfall Input prices Price received	Weather and climate (especially frosts)	Rainfall Cattle prices Pasture insect pests
16	10	All have a significant impact, the extent to which this impact effects production and profitability varies between seasons.	Cropping: 10 Livestock: 7-8	Rainfall: 10 Prices: 6 Pests: 5

5.3.4 Model predictions

When the models developed in Chapter 4 where applied to each of the case studies there were some differences in predicted and actual results that would be of a practical significance. These are outlined in Table 5.3 and considered in the Discussion section, below, in the context of the NRM survey responses obtained from the case study enterprises.

Table 5.3 Predicted and actual values of selected variables for case study farms

Variable	Farm 1	Farm 1 P	Farm 2	Farm 2 P	Farm 3	Farm 3 P	Farm 4	Farm 4 P
Return on assets (%)	1.3	2.3	1.1	1.7	1.4	1.4	1.7	0.7
Return on Equity (%)	-1.3	-1.9	1.1	3.5	-2.5	-3.35	-3.7	-0.48
Operating profit per ha ($/ha)	-219	-17*	106	133	-177	-177	-86	9
Operating profit margin (%)	-32	-37	20	50*	-106	-80*	-50	-20*
Equity level (%)	100	102	100	80*	90	90	80	80
Stocking rate (DSE/ha)	26.1	19.1*	19.2	16.5	14.4	15.3	14	12.4
Cost of production per kg LW ($/kg)	1.60	1.30	1.00	1.50	3.00	2.80	1.70	1.70
LW of beef produced per ha (kg/ha)	577.3	426.6*	404.2	445.7	115.2	222.7*	147.6	264.2*
LW of beef sold per ha (kg/ha)	1017	1000	382	471.7*	139.8	339*	184	150
LW of beef sold per DSE (kg/DSE)	39	33.6	19.9	26.8	9.7	8.7	13.1	15.8
Core per DSE cost ($/DSE)	10.00	9.20	3.50	4.60	4.40	6.10*	5.30	5.50
Core per ha cost ($/ha)	319	286	109	206.6*	130	118.9	74	132.5*

P Predicted value

* Significant practical difference between predicted and actual values

5.4 Discussion

The four case study farms reflected some of the variation between enterprises that exists within the Tasmanian industry. The North-West coast of Tasmania typically has higher annual rainfall and soils that are more fertile than the Meander Valley. Despite the geographical separation of Farm 1 and 2 from Farm 3 and 4, there were strong similarities in the natural resources and environmental issues identified as being significant to farm management and performance. All four case study farms recognised the importance of their natural resources and the need to manage them appropriately.

5.4.1 Production and profitability

Farm 2 was more profitable than the other three case study farms and was the only case study farm to have a positive operating profit. Farm 1 and Farm 2 both had a greater SR and production per ha than Farm 3 and Farm 4. The increased productivity and carrying capacity of Farm 1 and Farm 2 is supported by the potential for increased pasture production resulting from slightly warmer mean annual temperature, higher water balance and annual rainfall, as well as having highly fertile soils (Pearson & Ison 1987). Respondents for all four case studies acknowledged the need to manage stocking rates according to the capability of the land and indicated that they based their SR on the lands capability to maximise the productivity per unit land area for long term sustainability.

The survey results were able to identify reasons behind some financial results such as the differences in COP and expenses associated with weed and pest control. Farm 2 had the lowest COP and highest equity, which is consistent with maintaining a low COP and debt levels as part of their farm management approach. As discussed in Chapter 4, COP is a key driver of profitability, the greater financial performance of Farm 2 can be related, in part, to the reduced COP.

The management of Farm 4, in comparison, was based on a low input production philosophy. This approach resulted in a lower core per ha cost than the model predicted, but maintained a high COP per unit output (through higher feed supplementation) and had a production of beef per ha half that of the State average. Despite lower production levels the control of costs did result in a relatively high return on assets.

5.4.2 Natural resource management

Similar natural resources and environmental assets were identified by all respondents as important to farm production and profitability. Likewise, common NRM issues were reported. Environmental assets were recognised by all four property owners as being very important to enterprise performance. Water, shelter for livestock and fertile soils were identified as some of the most important natural resources on each case study property, having an impact on both farm production and profitability. Identification of these variables is consistent with previous findings relating to water availability and soil characteristics as being significant drivers of productivity and hence profitability (Pearson & Ison 1987). The use of both native and planted vegetation for livestock shelter is a common practice in agricultural regions throughout Australia and is regarded as a valuable environmental contribution as well as providing shelter to livestock from the effects of adverse weather conditions (Gillespie *et al.* 2008). The use of fencing to protect shelterbelts, remnant vegetation, dams and watercourses was reported for all four case studies. This practice occurs throughout Australia and has been encouraged through government NRM funding opportunities (Gillespie *et al.* 2008). Fencing had also been used on the case study properties to enable paddocks to be grazed according to their capability. The risk of soil erosion and soil degradation was reduced through ensuring paddocks were not over grazed.

The management of environmental assets perceived to not be directly related to income generation was not regarded as high a priority compared to those assets and environmental issues affecting production.

As has been reported previously (e.g. ABS 2008), constraints in financial resources and time were identified as significant limitations to the implementation of NRM practices. To obtain information and financial resources to assist in the management of natural resources and environmental problems, farmers have commonly used organisations and Government initiatives such as Landcare and regional NRM groups (Mitchell *et al.* 2007). All four case study enterprises had used such resources at some point, in particular for funding to fence off watercourses and for tree planting. The general view from all four case studies was that, although there is information and funding available, the financial support is still inadequate. If there was more funding then there would be a greater incentive and justification for dedicating time and resources to natural resource management. Again, this finding is consistent with previous research (ABS 2008; Gillespie *et al.* 2008) suggesting that a lack of financial incentives is one of the key barriers to producers undertaking NRM on farms.

Weeds and pest animals were identified as issues for all four case study properties. Controlling these problems was considered costly and time consuming and, as a result, had a high impact on farm production and profitability. There were no figures available on the exact losses incurred as a result of these issues. Present studies assessing the impacts of browsing animals on pasture losses have indicated there to be significant production and economic losses (Norton 2009b).

5.4.3 Farm management and risk assessment

A number of socio-economic and environmental factors were regarded as important to farm management and risk assessment. The managers of all four of the case study farms had a very positive approach to their management. It was a genuine passion for farming and a desire to pass the farm on to the next generation that maintained their interest in farming. Given the relatively poor ROA for these businesses, it is not unexpected that non-financial concerns drive the motivation to continue farming. Succession planning has been recognised previously as a driver of longer-term sustainability and a positive influence on the implementation of sustainable farming practices (Taylor *et al.* 2000; Stanley *et al.* 2005). Similarly, the approach to risk management by the case study farms recognised the need for long term productivity and sustainability rather than mere short term gains. This philosophy was implemented by each of the case study enterprises through careful analysis of any potential management changes and by regularly assessing the risks associated with various management practices.

Farm 1 and Farm 2 regarded running solely a beef enterprise as part of their risk management profile, while Farm 3 and Farm 4 considered running multiple enterprises as part of their risk management. Research into risk and specialisation has previously shown that enterprises specialising in livestock production have a reduced variability of financial performance, but also had a decreased mean financial performance (Purdy *et al.* 1997). There is no evidence to suggest that having a single industry-based enterprise is preferential to supporting multiple industry activities.

Personal interest and skill sets of property managers are important factors in determining enterprise choice. Key to the risk management of all four case study farms was the conservative approach to adopting new or varied practices. All of the case study farm respondents reported that the adoption of new practices required careful consideration and assessment to determine if the changes would be suitable to their individual situation. Despite this, the reported stocking rates on the farms were greater than that predicted by the focus farm results, with the exception of Farm 3, which suggested a degree of risk taking by those enterprises.

5.4.4 Model application

The use of the models developed in Chapter 4 to predict profitability and production variables for the case study farms identified a difference between some predicted and actual values that would be of practical significance. These included operating profit measures (OP margin and OP/ha) and productivity per ha. In some instances the difference between predicted and actual results was more than 100%.

Given the R^2 values of some of the developed models, some variation between the actual and predicted results was expected. The implication of this concerning the utility of the developed models is that, although the developed models are useful indicators they are not exact. A larger, industry wide, data set could strengthen the developed models and therefore improve their capacity to accurately predict productivity and profitability variables for individual enterprises.

The differences between predicted and actual values for productivity and profitability values can be used to highlight aspects in which the enterprise may be performing either above or below the theoretical potential. For example, the predicted and actual values for SR were comparable for the case study farms except for Farm 1 which was stocked at a higher density than the model predicted. This does not necessarily imply that Farm 1 is overstocked. Determining the ideal SR for any farm requires detailed assessment of the individual property and management practices, such as detailed soil analysis, and pasture production and quality. This information was beyond the scope of this study.

5.4.5 Conclusions

Decisions regarding management of natural resources are complex; and so the level to which the four case study farms represent the total industry is unclear. Despite the small sample size, the results from the interviews provided insights into the natural resources and environmental issues that producers regard as the most significant to their enterprises. Survey results from this study relating to natural resources and environmental issues were, in general, consistent with previous findings reported in the literature. The results illustrate some approaches to risk management that producers may adopt. The comparison of results from the models developed in Chapter 4 with the actual practices found on the case study farms indicated that the models can be of practical use to individual producers. For example, the models can be used to help identify areas in which enterprises may be performing below their theoretical level and, therefore, where improvements may be achieved. This study also indicated the influence that management philosophy may have on production and financial outcomes.

6. General discussion

6.1 Introduction

The Tasmanian beef industry is experiencing many pressures that may significantly affect its long-term viability. Improving current understanding of the relationships between agricultural productivity, profitability, and the biophysical capacity of the land used for production is considered important for the future development and security of the industry. This thesis undertook research to address this perceived need by examining key productivity and profitability drivers of beef production in Tasmania through the integration and analysis of farm financial and biophysical data. The thesis had four main aims including to identify key factors affecting productivity and profitability of beef enterprises and to examine the utility of GIS and spatial modelling for assessing farm business performance and scenario analysis in the beef industry.

Farm financial data for the 2006/2007 financial year of 27 beef enterprises were obtained through a financial benchmarking process. Additional data relating to enterprise management were also collected using a questionnaire. Biophysical data for each property was derived using GIS processes. Data from each enterprise were integrated and statistically analysed to identify correlations between financial performance and biophysical capacity of the land. To gain an understanding of how well the enterprises represented the State-wide industry, and to map landscapes suitable for supporting profitable beef enterprises in the state, GIS was also used to characterise the overall beef industry in Tasmania.

Building on this exploratory analysis, case studies were used to study in more detail the relationships between financial, biophysical and management data at an enterprise level. Based on Australian Bureau of Statistics protocols, additional information relating to management philosophy, environmental assets and natural resource management was collected for these enterprises. The suitability of GIS applications for decision support and scenario analysis was evaluated using data from the exploratory analyses, and information from the case studies in conjunction with the landscape mapping and characterisation of the Tasmanian beef industry.

6.2 Major findings and implications

Analysis of the financial data for the Tasmanian beef industry has shown significant variation in the productivity and profitability of beef enterprises. Statistical analysis of the financial data with the biophysical data identified a number of correlations. The proportion of land that is improved pasture, the proportion of relatively high or low fertility soils and the efficiency of beef production (Kg/ha) were strongly related to the profitability of an enterprise. Reduced risk, through increased operating profit margin and reduced cost of production, were explained in part by increased efficiency of beef production and land area. Stocking rate was strongly correlated with biophysical attributes that influence pasture production - in particular, area under irrigation, mean annual rainfall and mean annual air temperature.

The overall beef industry analyses for Tasmania generated detailed information on the landscapes supporting the industry that had previously not been available. This information confirmed the relatively diverse range of landscapes that the beef industry covers (ANRA 2007). Analysis of the areas that would be suitable for beef production illustrated the potential for further expansion of the beef industry in Tasmania. Although these findings demonstrate the possibility of industry expansion it does not infer that this would be the most profitable land use. Further analysis of the return on investment for different enterprises, in those areas and the potential implications that expansion of the industry may have on both income and expenses will provide industry with an indication of the level of sustainable expansion that could occur.

Based on the integration of financial and biophysical characteristics to identify correlations, the occurrence of some variables in multiple models indicated the possibility to use them as indicators of potential productivity and profitability. These variables include COP, liveweight production, SR, temperature, water availability (rainfall and water balance), relative soil fertility, and the proportion of different land uses. These variables have previously been identified as being significant drivers of enterprise performance (Kannapiran 2001; Newman & Chapman 2001; Holmes *et al.* 2008; McEachern *et al.* 2008). Unlike previous studies that have generally focussed on the southern Australian beef industry as a whole, this study provided an analysis of the relationship these variable had with farm performance specific to the Tasmanian industry.

The results of this study have indicated the areas in which the greatest improvements in enterprise performance could be made. Improvements in COP, and maximising productivity per unit area of land provide opportunity for some enterprises to improve their performance.

The differences between many variables for the top 25% enterprises and the 'average enterprise' as well as the wide range in values for many variables highlight the potential areas for enterprises to improve their productivity and profitability. In general, these are maximising production per ha, optimising SR and increasing productivity whilst controlling costs. For individual producers to obtain the greatest value from these data, assessment of their performance in relation to the top 25% and average values provides valuable information on the strengths and weaknesses of their business. For confidentiality reasons it was not possible to present individual enterprise results in this report.

Using four case study farms from NW Tasmania and the Meander Valley, it was shown that many of the models could be applied at an enterprise level with an acceptable level of accuracy, although further evaluation is required. The case studies provided information on the issues surrounding management of natural resources and environmental issues, management philosophy and its influence on model prediction, and risk management. Findings from this study were consistent with those reported for previous NRM studies in Australian agricultural landscapes (ABS 2008; Gillespie *et al.* 2008). The identification of characteristics that influence productivity, such as soil fertility and water availability, as being significant natural resources on properties indicates that producers have an understanding of the landscapes supporting their enterprises and the influence they have on productivity and profitability. Some of the issues associated with undertaking NRM practices that generally do not generate direct farm income (as perceived by enterprises) were indentified in this study and, again, appear consistent with those reported elsewhere (ABS 2008; Gillespie *et al.* 2008). These results suggest that further advances in on-farm NRM may be achieved through increased incentives to producers.

This project has shown GIS and spatial modelling to be an effective method for identifying statistically significant biophysical variables that help explain the performance of beef producing enterprises in Tasmania. The advantages provided by GIS for farm enterprise management and landscape assessment demonstrated here include the ability of the technology to assemble and analyse complex biophysical data sets; act as an integrating technology for evaluating financial, environmental and social data for benchmarking farm performance and management; and providing the ability to generate predictions across agricultural landscapes and over time for decision support and industry scenario analysis.

6.3 Issues and limitations

One of the issues encountered with this study was the difficulty in establishing a sufficiently large data set for comprehensively benchmarking the beef industry in Tasmania. Due to the limited participation from producers the analysis was restricted to an exploratory analysis rather than a complete industry overview. A larger data set would most likely strengthen the relationships identified. Use of an independent data set to test the models would also be beneficial in increasing confidence in model application and would be the next logical step in the development of this research.

Initially, it was intended that all benchmarking data would be collected through accountants. This technique proved ineffective due to a lack of participation from accounting firms. Methods directly targeting producers were implemented in order to increase participation rates for the data collection. Without doing in depth surveys and sociology studies it is not possible to identify the specific reasons for the lower than expected participation rates. Anecdotal evidence suggests that this may have been in part due to the poor seasonal conditions on-farm and the lack of time available to farmers to support the study. These seasonal conditions caused many producers to have relatively poor productivity and profitability performance, and increased pressure on time resources. As such, a view that involvement in the project was not a priority may have been one of the reasons for difficulty in gaining producer involvement.

The models developed for the 06/07 data set were not able to be used to accurately predict profitability and productivity values for the 07/08 data set for individual enterprises, even though they were included in the data set used to generate the model. However, some of these models were regarded as being sufficiently accurate to be used as a general industry indicator. The inability to use the developed models to accurately predict results for 07/08 year does not necessarily mean that the models are inaccurate. It does, however, highlight the possibility that there are other influencing factors that were not accounted for in the modelling process. This is also reflected with some of the models having lower R^2 values. Both 2006/2007 and 2007/2008 were regarded as drought years and this was expected to have been an influencing factor on enterprise performance. Re-analysis of the long term rainfall data in relation to pasture production and pasture quality may have improved predictions of farm performance, but was not possible during the present study. This is an area warranting further investigation and might assist future ambitions by industry to assess the implications of climate change on beef enterprises.

Economic analysis of various agricultural commodities (including beef) are regularly produced (Holmes *et al.* 2008; ABARE 2009a, 2009b). These reports provide concise information about the beef industry. One of the issues encountered when using results from these types of studies for comparative purposes is the variation in profitability measures and calculations used for reporting. This reflects the need for more consistent, if not uniform approaches, terminology and calculations in benchmarking activities undertaken by government and industry reporting bodies (RIRDC 2000; Ronan & Cleary 2000; Newman & Chapman 2001). This would allow for much more thorough comparison of trends.

GIS is regarded as an effective source of spatial information and can be used to provide detailed analysis of agricultural landscapes (Delaney 1999; CRCSI 2007; ACIL Tasman 2008). One of the issues encountered in this study was the currency of spatial data. Despite using the most up to date data sources possible, difficulties were encountered when the PIDs provided were not able to be located in the GIS database. With time, this problem was able to be rectified using the easting and northing values for the properties. The issue arises because of the inadequate system used to assign and maintain PIDs for land parcels in Tasmania, especially when subdivision and amalgamation of land parcels results in changes to the PIDs.

6.4 Future research

This study indicates the benefits that could be obtained from the collection of further farm performance information. The benchmarking process provided a significant amount of information relating to enterprise performance whilst the landscapes supporting these enterprises were characterised through the GIS analysis. Spatial information such as rainfall and temperature can be used to estimate factors influencing production potential. However, it cannot account for paddock management including fertiliser application or pasture species and composition. Such management practices impact upon both productivity and profitability (Bird *et al.* 1989; Graham *et al.* 2003). Collection of the latter data would require more in depth data collection for each enterprise. While such an investment was beyond the scope of this study, the findings of the study indicate the benefits that could be obtained from further in depth work.

6.5 Conclusions

This thesis demonstrated that the benchmarking process and GIS techniques and technology are effective methods for data integration and the examination of farm financial performance in relation to environmental capacity. The potential for further research, particularly relating to paddock management factors, is evident. While the benchmarking results remain exploratory, they do provide an insight into the state of the Tasmanian beef industry and the factors underlying its productivity and profitability.

Appendices

Appendix 1 Geographical map of Tasmania

Scale 1:1,000,000

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