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The impact of climate change on farm business performance in Western Australia

Understanding farmer's adaptation responses and their key characteristics in response to a changing and variable climate

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Abstract— **This study examines ten years of financial and production data of 249 farm businesses operating in south-western Australia. It also identifies the behavioural characteristics of the farm operators through a comprehensive socio-managerial survey of each farm business.**

The study area has a Mediterranean climate, where three quarters of the rainfall is received during the growing season from April and October. Growers have learned to produce 2 tonnes per hectare of wheat on less than 200 ml of growing season rainfall.

Australia is the driest continent in the world and is renowned for its climate variability. In addition, evidence is emerging that its southern parts, like south-western Australia, are experiencing a warming, drying trend in their climate. Average annual rainfall over the last thirty years in the study area has declined and average minimum and maximum temperatures have risen. Moreover, in the last ten years a number of droughts have occurred.

This multidisciplinary study examines the business performance of 249 farms from 2002 to 2011 and identifies the strategies farm managers have adopted to adapt to a drying, warming environment. Farms are categorised according to their performance. Their characteristics are compared and contrasted. We find many significant differences between farm performance categories and the adaptation strategies used by the farmers in each category. There are also different socio-managerial and behavioural characteristics between the groups of farmers identified.

Keywords— climate change; farm performance; behavioural characteristics.

I. INTRODUCTION

Australian farmers face two major climate risks: climate variability and climate change. Climate variability refers to the short-term fluctuations in temperature, rainfall and other climatic conditions over a season or across years. In contrast climate change describes the longer term trends (decadal or longer) in the underlying climate [1]. Australia's climate is recognized as one of the most variable in the world [2 & 3] and as a result it is one of the greatest sources of risk for Australian agriculture [1 & 4]. Long-term climate change for southern Australia is projected to involve an increase in temperatures and decrease in rainfall. This projected warming and drying trend, has already begun to be observed in southern Australia [5, 6, 7 & 8] and is complemented by increasing atmospheric concentrations of carbon dioxide (CO_2). Contemporaneous with this unfolding change in climate, farmers have experienced a period of marked volatility in farm product prices since the late 1990s [9 &10] Against this backdrop of price volatility and climate challenge, farm businesses in Australia have also needed to cope with the business pressures arising from a strong Australian dollar, scarce farm labor and an ageing farm workforce; all factors adding to the challenge and complexity of broad acre farming [9].

This study examines the impact of the above issues on the financial performance of 249 broad acre farms in Western Australia located in the shaded area shown in Figure 1. Their financial data is complemented with data from a socio-managerial survey completed by farm consultants who have worked with the family farm businesses in the same period. The aim of the study is to understand and identify the different characteristics of farms and their capacity to adapt to climate change.

A. The study region

A Mediterranean climate prevails, characterized by long, hot and dry summers and cool, wet winters. In the northern and central parts three-quarters of the average annual rainfall is received between April and October. Summer rainfall is highly variable, and is more common along the south coastal parts of the region. (Figure 1)

The farming systems are mixed grain and livestock, predominantly sheep enterprises, only 23 properties in the sample data had cattle at the end of the study period. Wheat, barley, canola, and lupins are often grown in crop sequences

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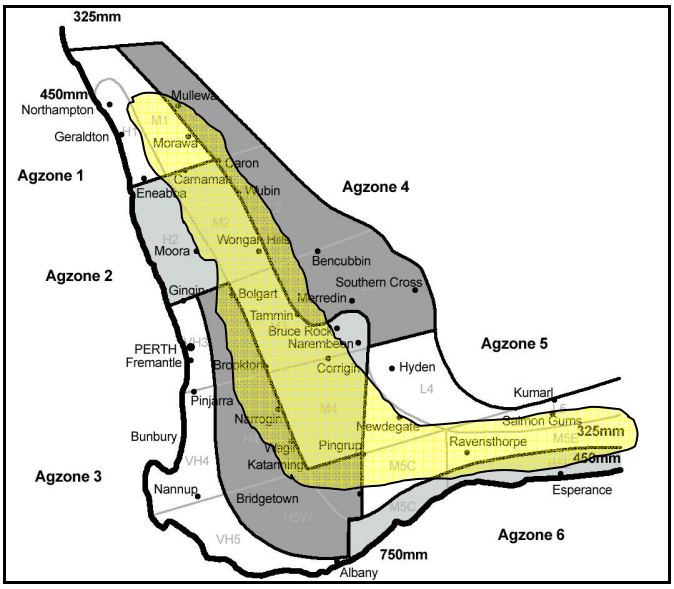

Fig. 1. Southern Agriculture region of Western Australia

rather than strict rotations. The area of lupins has decreased substantially in recent years due to their poor profitability. By contrast, the area of canola has increased due to improved varieties, better agronomic practices and good profitability.

Sheep are run on annual pastures during winter and spring. In summer months, livestock feed on pasture residues and crop stubbles. In late summer through to early winter there is often a feed gap and grain supplements of lupins or barley are fed to maintain animal welfare. The quantity and quality of pasture produced is mainly influenced by the timing of the first winter rains known as "the break of the season", soil type and management. When the break of the season is early pasture production is greater.

B. The climate of the study region

Figure 2 shows the annual mean temperature anomaly in south-western Australia from 1910 to 2012, indicating a warming trend.

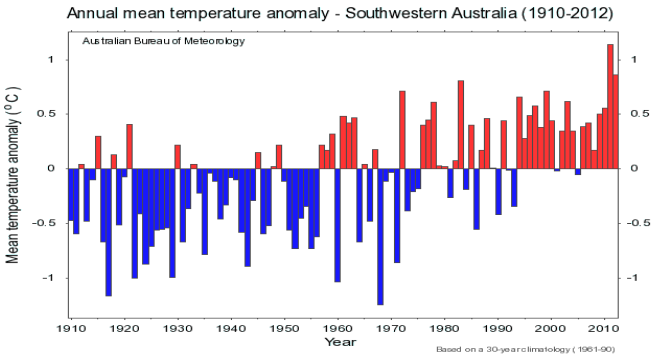

Fig. 2. Annual mean temperature for SouthWestern Australia (1910-2012)

Accompanying the warming trend has been a drying trend as illustrated in figure 3.

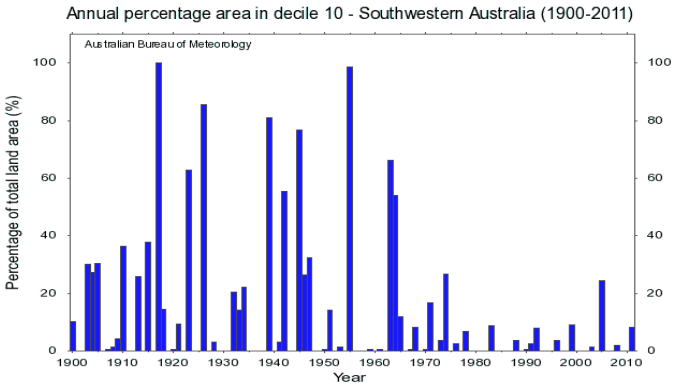

Fig. 3. Annual percentage area in decile 10 (1900 -2011)

Most parts of the south-western region have not experienced extremely wet years since the 1970's (i.e. decile 10 rainfall years). The absence of wet years makes runoff into farm dams problematic and lessens soil moisture reserves, making plant growth very dependent on growing season rainfall, and making crop yields more vulnerable to spring conditions. Moreover, the overall trend in annual rainfall is downwards. The region's expected annual rainfall at the start of the 1900s was around 750mm. Currently, the trend value for annual rainfall is around 620mm. This drying trend is observed throughout the southwest region, from inland to coastal parts.

Besides weather-year variation and its underlying warming, drying trend, farms in the study region also have faced pronounced price volatility, especially for grains. This volatility has been a global phenomenon [9].

Since the mid-2000s large changes in grain prices have been observed. For example, in the early months of 2008 the cash price for wheat peaked at A$430 per tonne yet towards the end of 2008 the price was as low as A$285 per tonne, a one third drop in price. Such volatility in price has greatly affected the profitability of grain enterprises and highlighted the very important role that grain marketing and price risk management now plays in grain production since Australia deregulated the wheat market in 2008.

II. METHODS

Farm business records of 249 farms were obtained from three farm consulting firms for the period 2002 to 2011. These longitudinal datasets describe the farm production and financial records of each farm over the decade. The data was carefully synchronized to ensure consistent variables were used across the three sources of data.

The sample sizes in the main zones represent around 15 percent of the farm population in those zones. However, it may not necessarily be truly representative of the wider farming community in each zone since the data is supplied from farms sufficiently viable to afford agricultural

consultants. The data may be upwardly biased if only above average farmers use consulting firms.

Complementing the physical and financial datasets of farm businesses were socio-economic and managerial data. These are client questionnaire assessments provided by the consultants. Because the farmers have been clients of the particular consultancy firms for at least the period 2002 to 2011, and because the farmers tend to retain the same consultant, often a close professional relationship between the consultant and their client exists. Accordingly the consultant is often well-informed about the socio-managerial environment that underpins the operation of the farm business and consequently they are well-placed to provide independent assessments.

The questionnaire was pilot-tested and revised before sending out to the consultants. A rich dataset of the socio-managerial characteristics of each business was acquired. The information collected includes the demographics of each business, training history throughout the period, cropping and livestock innovations implemented, technical innovations used and business and time management skills evaluated.

Often farm performance is assessed and reported on an annual basis. Rarely, are metrics used that consider longer term performance. Benchmarking and farm survey reports are usually based on annual samples that can change in size and rarely is the same set of farms compared through time. In this paper we examine the same 249 farms over a decade.

We employ five categories of farm businesses performance, adapted from Blackburn and Ashby [11]. The categories of farm performance are described as growing, strong, secure, less secure and non-viable. The derivation of these categories is shown in Table 1. The operating surplus/deficit is calculated as gross farm income minus variable costs and fixed costs. Profit for each year is calculated by subtracting the cost of finance (interest), personal expenses of the business and depreciation (calculated as 10% of total machinery value for the year), from the operating surplus.

TABLE I. FARM PERFORMANCE DEFINED

	Growing	Strong	Secure	Less Secure	Non-viable
Operating surplus	✓	✓	✓	✓	
MINUS					
Finance (interest)	✓	✓	✓	✓	
Personal expenses	✓	✓	✓	✓	
Depreciation	✓	✓	✓		
EQUALs Profit	+ve	+ve	-ve	-ve	-ve
EQUITY	Increase	Maintain	Maintain or Decline	Decline	Decline

The change in equity was calculated as the difference between net assets in 2002 versus their value in 2011, using constant land values based on the values in the first year, 2002. A business which achieved a profit at least seven years in ten and showed a real increase in equity from 2002 to 2011 was classified as a growing business. The distinction between a growing and strong business was that the strong business only maintained equity and achieved a profit in six of the ten years. Secure businesses could pay for their personal expenses, finance costs and depreciation but they made minimal profit and their equity was either maintained at a constant level or decreased over the period. Less secure businesses failed to achieve a profit after allowing for their finance cost, depreciation and personal expenses. Their equity declined as a consequence.

If an operating surplus is not achieved consistently over a period of time, the viability of the farm is eventually questionable. However it is possible to have a bad year or a number of bad years where an operating surplus is negative and equity declines, but the business can eventually recover if sufficient profit is subsequently achieved.

The farms are categorized using the five categories outlined in Table 1, 64% of the sample farms are classed as growing (40%) or strong (24%). There are 23% classified as secure and only 13% are in the less secure category. Although some farms experienced bad years during the period where they did not achieve an operating surplus, none of the farms in the sample is categorized as non-viable. This last result may be an artefact of the source of data. Due to requiring a decade's worth of observations on each farm business, this necessarily excluded businesses that were unviable and who left farming during the study period.

The farms were also categorized by farm type; crop specialists, livestock specialists and mixed based on their dominant land use. The majority (72%) of the farms were mixed where they cropped between 40% and 80% of their land. Twenty per cent of the farms were crop specialists, some with no livestock and 6% were livestock specialists only cropping 40% or less of their farm land area.

When farms are categorized on the basis of farm type and performance, the findings show that all three types of farms are growing. However a higher proportion of crop specialists are growing but a higher proportion are also less secure, implying there is additional risk in specializing in a crop dominant production system. Whereas, the livestock specialists are more likely to be in the secure group (38%), and fewer are less secure (8%). Although they are less likely to have financial difficulty they are also less likely to be in the growing or strong groups. This reflects the lower profitability but also the lower volatility of a livestock dominant production system.

The mixed farms are the largest group (72%) of the sample and have the highest proportion of less secure businesses (16%) than either the crop specialists (10%) or the livestock specialists (8%), see Figures 4. However, the majority of these businesses (64%) are either growing or strong and 36% are secure or less secure. There is only 8% of livestock specialists

classified as less secure but a large proportion are only managing to maintain their equity levels and are considered secure.

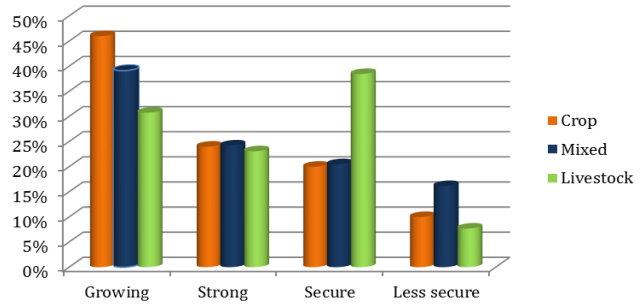

Fig. 4. Farm performance by enterprise mix

Crop specialists are out-performing the other groups and 45% are growing their businesses, but a cautionary note is required around this observation because crop specialists also have 10% of less secure farms. (see Figure 4)

When farms are categorized by region (see Figure 5), the observations to note are: The northern agriculture region, particularly the zone M1 is performing very well and more than 50% of farm businesses are growing, 71% of these businesses are crop specialists and mostly large farms, the remainder are mixed farmers. Less secure businesses in this region are not present in this sample. The central wheat belt area, zones M2, M3, and M4 (see Figure 1) all have less than 20% growing and in the M4 region it is less than 10%. M2 however, has a large proportion of strong businesses where 50% are either strong or growing.

More than 50% of farm businesses in the M5, H4 and H5 are either growing or strong.

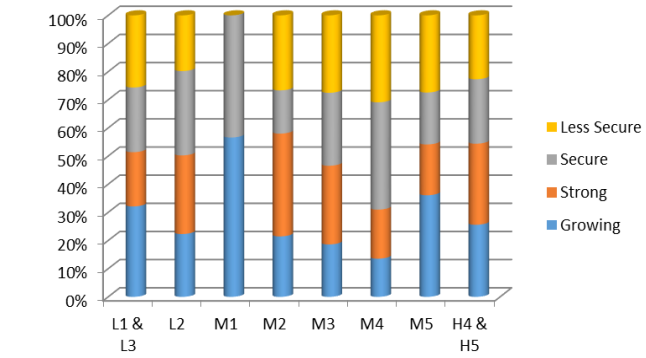

Fig. 5. Regional farm performance

On average the farms in all four performance groups increased their crop area from 2002 to 2012. The growing group of farmers have the highest cropping area as a percentage of farm area. They started with the highest area in 2002, with an average of 65% of their land being allocated to crops. By 2011 this average area increased to 85% of their land. They have also increased their cropping areas the most, compared to the other three groups.

However, the downside to increased cropping areas is the increase in revenue volatility. The variation in average profit for crop specialists who are growing see an increase in the standard deviation for the average profit which shows that greater profitability is associated with increased crop area yet also increases volatility in profit and therefore risk increases.

- There is a reward for increasing risk but there is also a penalty with increased volatility, also observed in the data with a higher proportion of less secure crop specialists compared to livestock specialists.
- There is a strong correlation with growing season rainfall [12] and yield potential, however a straight line relationship does not exist and factors like the distribution of rainfall across growing season, size and distribution of rainfall events, water holding capacity and soil type all effect yield outcomes [13].

Applying the farm performance classification criteria outlined in Table 1 to the dataset generates the results in Table 2. The mean values of each main characteristic of farm businesses in each of the four categories of farm performance are listed.

TABLE II. MEAN FARM PERFORMANCE FOR THE GROUPS

		Growing	Strong	Secure	Less secure
	Unit				
Gross farm income	$	1,577,486	1,204,430	1,070,855	791,490
Operating costs	$	996,072	808,160	730,798	594,360
Operating surplus	$	581,414	396,270	340,057	197,130
Profit	$	273,090	138,128	114,573	- 43,983
Personal Expenses	$	111,752	105,847	83,202	84,701
Interest payments	$	81,477	52,699	58,261	81,524
Machinery replacement	$	115,259	99,596	84,021	74,439
Debt to income ratio	no.	0.99	1.05	1.35	1.64
Operating expenses as a % of gross farm income	%	69.5	73.1	79.3	91.9
Land owned	ha	3,875	3,422	3,093	2,739
Land operated	ha	3,935	3,502	3,269	2,660
Land value	$	4,685,816	4,496,043	3,557,352	3,276,747
Farm assets	$	6,987,197	6,202,225	4,864,321	4,608,275
Business assets	$	7,717,971	7,048,667	5,356,378	4,985,611
Liability	$	1,417,091	1,193,862	1,389,985	1,213,838
Equity	$	6,431,107	5,743,213	3,963,110	3,749,779
Equity as a %	%	82.4	82.2	75.6	76.7
Crop area	ha	2,826	2,313	2,188	1,770
Pasture area	ha	1,110	1,190	1,081	890
Crop Income as % of farm income	%	80	77	76	74
Crop income per ha	$/ha	464	427	403	379
Livestock income per ha	$/ha	250	201	295	255
Farm asset value per ha	$/ha	1,853	1,963	1,646	2,040
Business asset value per ha	$/ha	2,054	2,194	1,815	2,200
Debt per ha	$/ha	375	393	429	515
Equity per ha	$/ha	1,709	1,768	1,376	1,677
Return on capital	%.	5%	3%	4%	-1%
Return on equity	%.	11%	8%	10%	6%

The seasonal impact on profit outcomes is significant and is shown by a gross margin analysis of the data.

The growing farms achieve more than $300 gross margin per hectare four years out of ten for crops. Despite the ten year average crop gross margin being less than the livestock $160/ha and $190/ha respectively, the years where more than $300/ha is achieved the business growth occurs. These farms were able to capitalize on the high prices with reasonable seasons to achieve high gross margins. The years this occurred are 2003, 2007, 2008 and 2011 which all coincide with good seasonal conditions, favorable terms of trade and high grain prices. The strong businesses achieve two years with gross margins above $300/ha, secure businesses only one year and the less secure businesses none.

Identifying the differences between these farm categories provides insight into the drivers for farm businesses success. It is interesting to note that five out of the ten years the growing business achieved the same result from livestock and cropping, it did not matter which enterprise they chose.

The enterprise mix and allocation of resources on farm is a choice made by farm business managers based on a number of factors such as prices, capabilities, land suitability and personal preferences i.e. dislikes and likes of types of work.

These decisions are mostly based around the farmers risk preferences in context of their individual circumstances and resources available to them. There is a clear impact of the enterprise mix on farm business performance. Gross margin analysis of the data reveals that achieving gross margins above $300/ha four years in ten allowed the business to grow. A few livestock specialists were able to achieve gross margins above $200 to $250 and generate growth.

Although not discussed here in detail, significant productivity differences between the groups of farm performance were found and between farm type. Crop specialists experienced productivity improvement from technical efficiency change; that is the adoption and adaptation of existing technology. The livestock specialists experienced no productivity improvement during the study period [14 & 15].

A comparison of the farm performance groups using the socio-managerial information collected about each family farm provides some useful and unique insights into the characteristics of farm businesses who are adapting to variable and changing climates. A strong correlation was found between the farm performance groups and their application of technology and implementation of innovations. The growing farms tend to look after their machinery better and are more organized. Their machinery is more likely to be ready for seeding in a timely manner, they have introduced more cropping innovations and for a longer duration of time and lease more land. The growing farms who are livestock specialists also implement more livestock innovations than the other groups. Growing farms, regardless of the type of farm are also more involved with their communities. Table 3 shows the results from the statistical analysis of the organizational and time management analysis.

TABLE III. RESULTS OF ANALYSIS FOR ORGANISATION AND TIME MANAGEMENT SKILLS

	Growing	**Strong**	**Secure**	**Less secure**	**P-value**
Seeding equipment ready to go	91	89	80	59	**0.000**
Header ready at harvest	90	89	80	75	**0.139**
Header cleaned and put away after harvest is finished?	84	77	67	69	0.108
Do they regularly service their tractors	88	87	85	81	0.825
How do you rate their plant and machinery care?	88	81	81	70	0.147
Do they take annual holidays and/or regular breaks?	69	52	60	67	0.221
Labor management	76	51	48	39	**0.000**
Work life balance	58	48	43	55	0.313
Office away from home	36	17	19	27	0.044
Is your client involved in the rural community?	72	65	60	45	0.052
Do they play sport locally?	51	42	34	30	0.124

There is a significant difference between farm performance groups in the way they look after their machinery. Growing farms are timely in their management practices by ensuring their equipment is ready for operational jobs like seeding, suggesting they have a high level of organizational skills. They also achieve a work/life balance. The growing group of farmers implement strategies which allow them to grow. They are more organized.

III. DISCUSSION

The growing farms when compared to the less secure farms tend to have the following key differences. Growing farms are larger, generate a higher rate of return to capital and equity, carry less debt per hectare, are slightly more crop dominant, have higher personal and machinery replacement expenses, have a much lower debt to income ratio, have slightly higher equity in percentage terms, generate similar livestock income per hectare but much higher crop income per hectare and overall generate much higher profits.

The practical implication of the finding is that it has not generally been possible for farm businesses to achieve a high mean in the operating surplus per hectare whilst simultaneously achieving little variance in the operating surplus per hectare. Hence, a farm business strategy of lifting the farm's mean operating surplus per hectare has necessarily involved an increase in the variance of the operating surplus per hectare.

The results show farmers who have a positive attitude towards taking risks by increasing their cropping areas will benefit from the upside associated with cropping and their businesses will grow. A risk-reward response is evident from the data; the businesses which have succeeded in growing their business during the ten year period have consistently increased their percentage of area cropped, but at the same time have experienced an increase in variability of profit.

A sequence of favorable production years will allow crop dominant farmers to produce their way towards business growth. However, there are some important caveats to the

findings of this study and that is the converse is also applicable. An increased frequency of very poor production years will eventually lead crop dominant farm businesses towards insolvency. Hence, the crucial issue for climate change is not just the trend in environmental change but, more importantly, the nature of the variation about that trend. An increased frequency in very dry years, for example, will undermine farm profitability. It is the farmer's response to these years and their ability to manage their business which underpins their ability to grow their business.

Each business is measured against itself at the start of the period. A comparison between businesses is not made. This unique study looking at longitudinal data does not make cross-sectional comparisons of businesses which are more commonplace in other studies. Inappropriate comparisons between firms with different resource base is avoided in the methodology employed and data used. However it is not possible in this study to provide a gradation with-in each group or distribution, therefore the growing group includes different types of farms and sizes which are growing at different rates, none the less they are growing because they are risk takers, use more innovations, are more organized enabling them to have a better work life balance and make management decisions which enable their business to grow.

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