



**ENHANCING THE ADOPTION OF TECHNOLOGY BY  
AUSTRALIAN GRAIN GROWERS**

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*"I have grown my 60<sup>th</sup> crop since leaving school at 13 years of age. I think the best time of my career was during the years 1949-1960 when rust was overcome in cereal crops, DDT cured blowfly and lice problems in the sheep flocks and most importantly Mixomatosis (sic) wiped out the rabbit problem."* Quote from survey respondent

## DECLARATION OF ORIGINALITY

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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 Jay Alister Cummins

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I have also been fortunate having been involved in farming systems development work in both India and Eritrea during this time, working alongside some incredible people who collectively face immense challenges well into the future. This has provided me with much inspiration to complete my studies, and in some way contribute towards the development of agriculture in their respective countries. Through these experiences, I have had time to reflect and review this course of study. It has been the ability to develop and share ideas and concepts over time that has assisted me in developing a much higher degree of understanding and outcomes from the research, that in time will be of benefit to the Australian grains industry and beyond.

## **ABSTRACT**

Factors that influence the adoption of technology by Australian grain growers are not clearly understood by research and extension professionals. Extension efforts often fall short of creating change, often limited to creating an awareness of new practices. The transfer of information frequently occurs in a linear fashion, despite the popularisation of farming systems approaches to group extension. This thesis aims to develop a better understanding of the adoptive behaviour of grain growers, through identifying socio-economic factors that influence adoption processes, and the identification of farmer typologies based upon a market segmentation approach.

Core data built via survey responses from 2,472 farming businesses (representing a response rate of 55.3% from a population of 4,470) provided the source of data and information for this thesis. This study has established a clear understanding of the behavioural characteristics associated with the target population in terms of adoptive behaviour, production capabilities, information seeking characteristics and innovativeness, with highly significant differences observed between the top 25% and bottom 25% of achievers.

The study has clearly identified characteristics of agricultural knowledge systems, including the influence of information providers, the quality and credibility of information, and social influences. In order to have an impact, information needs to be sourced from credible sources that are characterised by independence, experience and a practical application of ideas and experience. Farmers value most information from other farmers, particularly in relation to innovations that require considerable adaptation on farm. Information that is provided from an independent source will be trusted more than when it is linked to a product or sale.

Past research into describing farming typologies has aimed to bring about a better understanding of behavioural characteristics (and change) amongst farmers. This work has had its limitations in terms of dealing with relatively small population samples and in some instances has lacked statistical rigour. This study has identified a range of farming typologies on the basis of the identification of the relationships between the measured characteristics of the target population, using a series of highly robust approaches involving principal component analysis and k-means cluster analysis. The formation of distinct clusters has brought about a relatively structured and unbiased segmentation of the target population. Respondents within clusters have personal and situational characteristics that have been identified through a statistically rigorous process, rather than being based upon perceived stereotypes.

The ability to identify a range of farmer typologies through a market segmentation approach (primarily based upon adoptive behaviour, personal and situational characteristics) will allow the development of a range of different extension approaches in a resource limited environment. Understanding why farmers behave the way they do will assist in explaining the logical reasons for non-adoption.

From the findings associated with this research study, there is an opportunity to develop a personal capacity and capability assessment tool; in order to help determine the ability of farmers and their businesses to cope with change, and assess longer-term viability. This will help to identify 'at risk farmers' in order to develop appropriate support strategies in order for them to retire from farming, or strengthen their coping mechanisms in order to maintain their preferred farming lifestyle, supplemented by off-farm income earning opportunities.

The fact that approximately half of the target population in this study do not have the capacity or capability to change presents the grains industry and government with immense challenges from social and developmental perspectives.

### **Abbreviations used in this thesis**

ABA	Advisory Board of Agriculture
ABC	Australian Broadcasting Corporation
ABARE	Australian Bureau of Agricultural and Resource Economics
AKIS	agricultural knowledge information systems
ANOVA	analysis of variance
APEN	Australasia-Pacific Extension Network
EEC	European Economic Community
GIS	geographical information systems
GPS	global positioning system
GRDC	Grains Research and Development Corporation
GSR	growing season rainfall
ha	hectares
kg/ha/yr	kilograms per hectare per year
kg/ha/mm	kilograms per hectare per millimetre
LWA	Land and Water Australia
MLA	Meat and Livestock Australia
mm	millimetres
MSMC	market segmentation model for change
NLP	National Landcare Program
NRM	Natural Resource Management
PCA	principal component analysis
PIRDS	producer initiated research and development sites
PIRSA	Primary Industries and Resources South Australia
PMP	property management planning
R&D	research and development
R,D&E	research, development and extension
RIRDC	Rural Industries Research and Development Corporation
SA	South Australia
SACBH	South Australian Co-operative Bulk Handling
SAFF	South Australian Farmers Federation
SARDI	South Australian Research and Development Institute

STD	Subscriber Trunk Dialling
t/ha	tonnes per hectare
UHF	Ultra High Frequency
UK	United Kingdom
USA	United States of America

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## Chapter One

### THESIS INTRODUCTION AND OVERVIEW

This chapter provides an introduction and overview of the thesis. In the first section an introduction to the nature of change in the grains industry and the problem statement are described. The second section presents the justification for the research. In section three the aims of the study are identified, leading to the general research questions posed in section four. Section five provides an overview of the research methodology, whilst section six provides an overview of the structure of the thesis.

#### 1.1 INTRODUCTION

The environment in which Australian grain growers operate is undergoing significant change and adjustment. The number of grain producing farms in Australia has fallen by 47% from 54,250 to 28,800 in the period 1977-78 to 2004-05, whilst the average areas sown to crop over this same period has increased by 95% to 660 hectares per farm (ABARE 2005). Productivity gains have been essential in order for farmers to buffer the impact of declining terms of trade. The need to develop improved farming systems has been critical to the continued improvement of sustainable production systems, in order to improve overall profitability on-farm.

There is a common perception amongst research and extension professionals that farmers have been slow to adopt new technologies, due to a highly conservative approach to farming (Black 2004, Cary et al. 2001). The less than desirable rates of adoption may be due to unrealistic expectations being placed upon the extension process, due largely to the complexities of introducing change on-farm (Vanclay 2004).

As a result, extension efforts have resulted in variable success, with change on-farm being most successful amongst those farmers who are perceived to have been progressive and innovative. The role and influence that extension has played in their success has been questionable, in that many changes that they have implemented may have occurred with or without extension playing a dominating role.

Whilst current extension approaches in Australia seek to promote the adoption of innovations through facilitating personal development of farmers in a learning environment, higher adoption rates have not eventuated (Kaine and Bewsell 2002). This has resulted in extension often being viewed as being responsible for such inadequacies. Government support and funding of extension services has decreased in recent years. It is considered that if this rate of decline continues, there is the potential that 80% of the farming population will be left with little access to information (Stone 2005).

In the past the transfer of technology has been considered by many extension professionals to be a one-way process, based upon a linear model of extension (Carr and Wilkinson 2005). Often there has been the underlying assumption that change in behaviour will take place once the information has passed between the source and the receiver (van den Kroon et al. 2002), representing the traditional technology transfer model. In transferring information to the farmer, little regard has been given to the total environment in which farmers make decisions. Many research and extension professionals have viewed non-adoption of technologies by farmers as a stubborn response to the valuable answers that research has produced. The frequent use of the term laggards (Rogers 1995) to describe such farmers has been indicative of the derogatory attitudes held by professionals utilising such a top down approach to extension. The whole concept of adoption, technology transfer and extension has been extremely reductionist in both concept and approach (Frank 1995a). Current understanding of the change process has failed to view the environment and its characteristics as a complex, interactive system.

In recent years the concept of agricultural knowledge systems has helped to increase understanding of how ideas and technology flow within an agricultural system. An agricultural system can be described as a community comprising farmers, their families, members of the local farming community, research and extension professionals, agribusiness representatives and other people who farmers communicate and interact with. Agricultural knowledge systems recognise both the contributions of science to knowledge, as well as the information that is generated from within a farming community. Unfortunately this understanding has been limited to academic research and teachings, with few extension professionals putting this theory into practice.

Rural communication networks are extremely active, with the exchange of information and knowledge taking place from farmer to farmer and across communities. It is essential that those involved in formal extension programs have an understanding and appreciation of the dynamic nature of such systems in order to further accelerate the transfer of information and uptake of improved farming practices. Farmer response to information can vary, influenced by the complexity of the technology, the context of delivery, and the level of credibility held toward the information provider by farming communities.

The traditional support structure for agriculture is rapidly changing due to withdrawal of government extension services, failure of farmers to adopt research outcomes and recognition of information as being of commercial value by agribusiness. This has adversely affected the degree to which information is shared and exchanged by stakeholders in any given farming community or industry. If this current situation remains, it is likely that farmer numbers will continue to fall as farmers exit the industry through an inability to remain financially viable, particularly in marginal farming environments where the incidence of drought is high. It is also likely that the sustainability associated with farming systems will break down, due to over intensification of agricultural production on fragile soils (Blaney 2004). It is evident that extension is at the crossroads: the development of an improved

environment conducive for change on-farm is of paramount importance if there is to be a future for agriculture, the economy and rural communities. Central to this is the development of a change model capable of building the confidence, capacity and capabilities of farmers, their businesses and the wider farming community.

There is a relatively poor understanding of the perceived barriers to adoption held by farmers. Barriers to adoption are symptomatic of the environment in which the farmer operates, characterised by both personal and situational factors which in turn influence the adoption process. Many professionals fail to understand how farmers deal with such a complex environment. The slow adoption of technology by farmers is often a natural behavioural response by them to managing a risky environment, and is a reflection of farmer conservatism.

This study is directed at addressing the characteristics of technology adoption by Australian farmers engaged in grain production. This study will focus on researching the characteristics associated with a target population of grain growers from South Australia, with the view of transferring the research findings and understanding developed in this study to the broader population of Australian farmers.

## **1.2 JUSTIFICATION FOR THE RESEARCH**

Organisations with an interest in achieving change amongst farmers through technology adoption programs invest considerable amounts of resources and effort into these processes, often with a poor understanding of achieving behavioural change. Extension programs to a large degree have tended to target non-specific audiences within the farming population, with little regard for taking into consideration the unique personal and situational characteristics of the farmer.

Often extension programs may be successful in creating awareness about a particular practice, but seldom progress beyond this stage of the adoption process. There has been a tendency to extend

information as part of a marketing approach to dissemination, under the presumption that "one size fits all" in terms of catering for all farmer needs. Whilst many efforts may capture the theory of communications and numerous change model processes, few if any extension programs capture a full understanding of the nature and characteristics of the audience, treating the targeted farmers as a homogenous audience.

The provision of extension services catering to the specific needs and characteristics of farmers is an expensive option, but so too are poorly targeted programs that aim to create a general level of awareness of farming technologies. This research study aims to address this issue, with the aim of developing cost effective extension delivery systems that enhance adoption processes leading to change on-farm. This research study examines in detail the relationships between farmer typology and adoption behaviour, through utilising market segmentation approaches that are responsible for influencing the change process.

Through developing a better understanding of the characteristics associated with agricultural knowledge systems, adoption processes and technology characteristics, it is possible to develop a strategic approach to initiating and supporting change in the farming community. This study is unique in that it aims to describe and present key elements in the adoption process with the view of developing capacity and capability assessment tools aimed at improving the skill base, and in turn the strategic development of enhanced extension systems. If this outcome is achieved, it will help to empower farming communities where capacity for managing change can be generated and driven from within rather than being imposed by an external influence. It is within this environment that this research study has been developed and conducted. The following provides an overview of the aims of the study, complemented by key research questions and the formal hypothesis for the study.

### 1.3 AIMS OF THE STUDY AND HYPOTHESIS

The aims of the study are to:

1. Improve understanding of the complexities associated with the process of adoption amongst farmers and determine if a market segmentation approach is valid in explaining adoptive behaviour and change amongst farmers.
2. Identify how specific personal and situational characteristics (including innovativeness, production capability and risk aversion) influence the rate of technology adoption and decision-making processes leading to adoption.
3. To identify and develop targeted systems of change for dryland agricultural systems in Australia through gaining an improved understanding of how farmers adopt new technologies that utilise effective agricultural knowledge systems.

This leads onto describing the hypothesis associated with this study:

#### **Hypothesis:**

The adoptive behaviour of farmers is influenced by the nature and complexity of the agricultural knowledge system, and personal and situational characteristics.

### 1.4 GENERAL RESEARCH QUESTIONS

This study will address the following questions:

1. Is it possible to utilise market segmentation approaches to describe farmer typologies on the basis of socio-economic characteristics and adoptive behaviour?
2. Do farmers differ in their personal and situational characteristics on the basis of their level of adoption, innovativeness and production capability?
3. To what degree are the adoption of technologies by farmers influenced by
  - (a) Characteristics of the agricultural knowledge system?
  - (b) Characteristics of the technology itself?

There are four groups of factors identified that are considered to influence the adoption of technology by farmers. These are:

- The personal and situational (socio-economic) characteristics associated with the farmer population (on the basis of a market segmentation approach and subsequent description of farmer types)
- The nature of the agricultural knowledge system (information source and environment of delivery, information seeking behaviours, characteristics of the information providers)
- Technology characteristics (complexity, ease of adoption, reasons for adoption / non-adoption)
- Farmer capacity to change, including production capability, innovativeness and risk aversion.

Relationships between adoptive behaviour and the personal and situational characteristics of the target population will be identified and described. It is proposed to develop a methodology allowing segmentation of the sample population based on the unique characteristics of each distinct group.

## **1.5 RESEARCH METHODOLOGY OVERVIEW**

In support of the research proposal an extensive review of related literature was conducted through the need to present to the reader a balanced view of available research and current knowledge gaps related to this study. This assisted in developing a framework for the research program, complemented by a model for the hypothesis and research methodologies.

Following on from the literature review a survey questionnaire was developed, in order to collect baseline data that addressed the research questions from farmers involved in grain production. Survey data was then analysed in order to identify relationships between personal and situational characteristics, the knowledge system, adoption characteristics and farmer behaviour.

Results from the survey and analysis were then reported back to selected farmer groups as part of a series of focus group workshops. This approach assisted in the interpretation of survey results and helped to generate a better understanding of the dynamics of decision-making processes and agricultural knowledge systems amongst the target population. At each of the focus group workshops, several case studies were also conducted, in order to provide qualitative information relating to the characteristics of local knowledge systems and farmer decision-making processes leading to adoption.

Following on from this, multivariate data analysis techniques were employed in order to apply a market segmentation approach to describing the survey population. This process identified specific clusters of farmers having similar characteristics, which then allowed clusters to be described according to farmer typologies. Discussion of the results and provision of recommendations completed the research methodology. A framework for the research methodology adopted in this study is provided in Figure 1.1. Presentation of the conceptual model is provided at the conclusion to Chapter two.

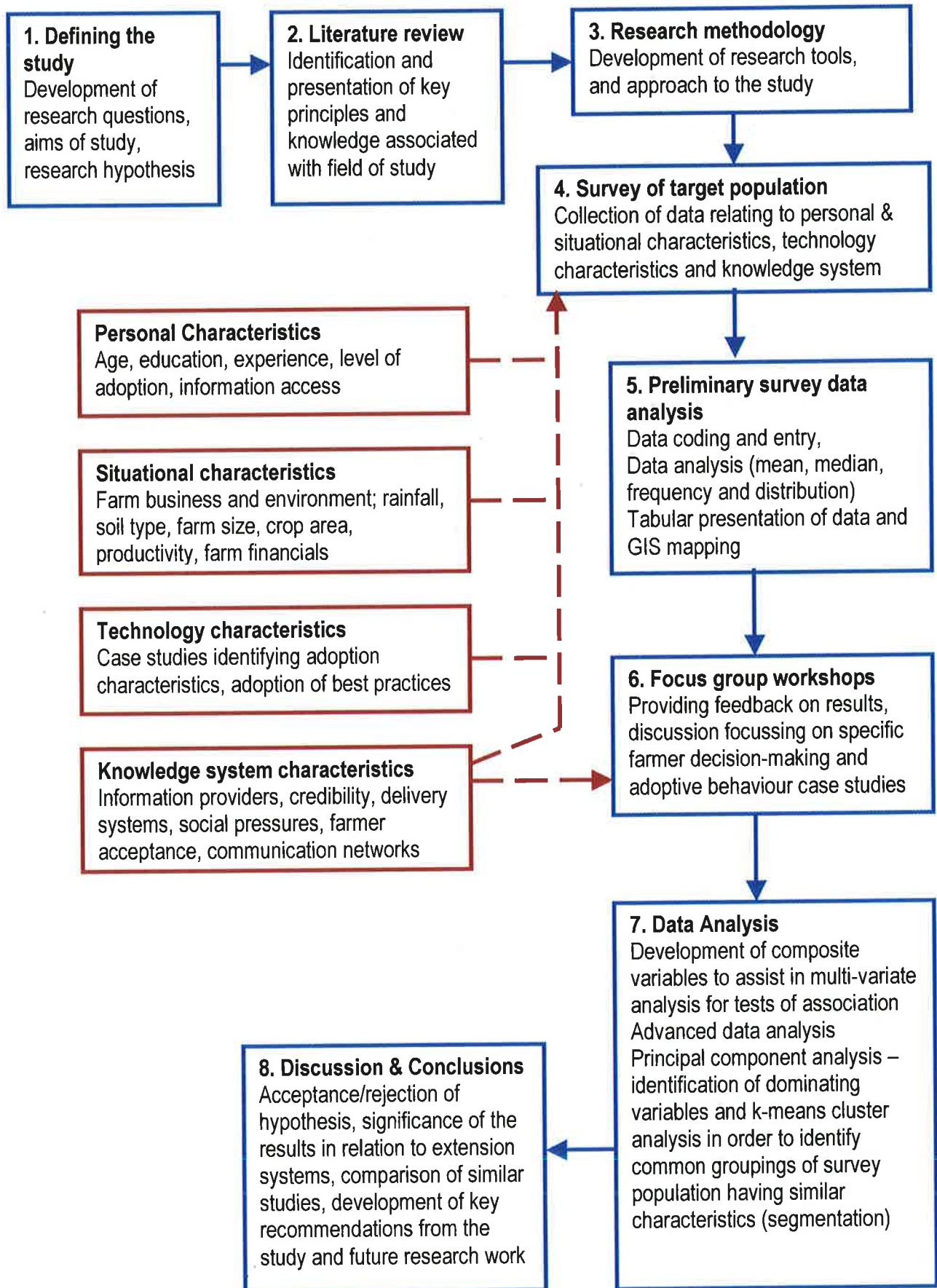
## **1.6 THESIS OVERVIEW**

This thesis comprises six chapters. Chapter one provides an introduction and overview of the thesis.

The literature review provided in Chapter two presents an overview of current knowledge and understanding in relation to the research topic. Key elements addressed include the nature and characteristics of adoption processes and behaviour, market segmentation approaches to describing farmer types and the characteristics of agricultural knowledge systems.

Chapter three provides a detailed overview of the research methodology used in this study, including survey design, data collection, and data entry and analysis procedures.

**FIGURE 1.1: A framework of the research methodology adopted in this study**



Chapter four provides a presentation of the results, analysis and discussion emanating from the survey questionnaire. Data presented in this chapter has a direct relevance to the research questions, conceptual model and hypothesis associated with this study. This chapter helps to build a better understanding in relation to adoption processes and influences, the nature of the knowledge system and the characteristics of the target population through identification of farmer typologies utilising a market segmentation approach.

Chapter five is dedicated to the provision of qualitative information summarising the results from a series of twenty-six focus group workshops. The workshops were conducted in order to assist in the interpretation and validation of survey results, and collect qualitative information in relation to behavioural characteristics associated with decision-making processes and local agricultural knowledge systems. The chapter provides an overview of the research methodology, presentation of results and discussion.

In Chapter six a summary of the key findings and outcomes arising from the study are presented, in terms of identification of those factors and characteristics that influence the adoption process, knowledge systems, and identification of farmer types based upon market segmentation techniques. This is then followed by a discussion in relation to the implications of the findings from the perspective of developing improved systems for agricultural extension delivery. Limitations to the study, suggestions for future work and final conclusions complete the thesis.

## Chapter Two

### LITERATURE REVIEW

The literature review is presented in eight sections as follows; the changing nature of the extension environment (section one); extension systems and change (section two); the nature of adoption and innovation (section three); agricultural knowledge system characteristics (section four); the social environment of technology adoption (section five); understanding farmer typologies (section six), key areas of focus for the study (section seven) and research questions and hypothesis (section eight). The chapter concludes with a conceptual model illustrating the relative complexity and associations between components of the system.

The first section provides an overview of the main issues and challenges facing agricultural extension from a range of stakeholder perspectives (since the second World War). This information is derived from a number of studies and assists in providing a number of definitions of extension and adoption. It is argued that traditional extension approaches are no longer valid, where government extension services have been replaced with farmer initiated research and development programs.

In section two, changes that have occurred in the provision of extension services by government and industry are presented, along with the key challenges associated with the provision of future services. This section concludes with the presentation of a range of extension models.

Section three focuses on the nature of adoption and innovation, and draws upon both Australian and overseas experiences. An overview of the characteristics of adoption and innovation in terms of identification of the critical success factors that lead to adoption, and the reasons for non-adoption are presented. Complexities associated with the adoption process are discussed in detail.

In section four the nature of agricultural knowledge systems are explored, reflecting upon both Australian and global experiences. The significance of providing independent and accurate information is highlighted as a critical success factor influencing adoption rates for new technologies and innovations. Community influences in terms of social pressures (associated with the adoption of technologies) are explored within the context of local agricultural knowledge systems.

Section five addresses the notion that technology adoption is influenced by the personal and situational (socio-economic) characteristics of farmers, which are linked to the elements relating to the nature of the information system (information source, the environment of delivery and the knowledge system) and the characteristics of the innovation itself (complexity, ease of adoption).

Section six provides descriptions of farmer typologies, based on farmer characteristics and the environment they operate in. Recent studies provide an up to date overview of the application and relevance of farmer typologies and describing adoptive behaviour.

Section seven provides a summary of the key areas of focus for the study, whilst section eight poses the research questions and hypothesis.

A conceptual model is developed in order to bring about meaning and greater understanding of the complexities associated with the adoption environment, providing a summary of key elements presented in the literature review and areas of focus for the research study.

## **2.1 THE CHANGING EXTENSION ENVIRONMENT**

The environment in which Australian farmers operate is undergoing rapid change. This has particularly been the case in relation to technology developments occurring since World War II. There are a number of distinct phases that have occurred during this period. An understanding of

the major challenges, innovations and developments that have occurred in each of these periods will provide an insight into the events and circumstances that have influenced the ways in which farmers respond to technology and adoption. This will help to bring about greater understanding of the factors that influence the adoption process. There is also the potential to identify farmers who have not been able to cope with the major changes that have occurred in agriculture during this period of rapid development. A description of the developmental phases having influenced South Australian (SA) grain growers are described in Table 2.1, and are summarised below.

### **2.1.1 Post-war agricultural land development period (1945 to 1960)**

The post-war period was characterised by the development of soldier settlement blocks with significant investment by government towards agricultural research, development and infrastructure. During the early 1950's, the South Australian State Government established the Land Development Executive, which was given the responsibility to clear and develop thousands of acres of land for returned service personnel (Kelly 1962). The Australian economy relied heavily upon agriculture during this period, with over 80% of Australia's export earning capacity being generated through agricultural exports, often described as 'riding on the sheep's back' (Productivity Commission 2005).

Agricultural extension was strongly influenced by the rapid development of Australia's rural industries. Rural society was experiencing a prosperous period of growth and earnings, aided by the post-war drive for development and record commodity prices. New technologies being adopted on-farm were largely simple labour saving tools, and included the use of herbicides such as 2,4-D for weed control and DDT for blowfly control in sheep (Bennett et al. 2002). Technology generally was offering simple and effective solutions to on-farm problems. The nature of the extension processes promoted were characteristic of a one-way flow of information to the farmer. This sentiment is captured in the following role statement for the SA Department of Agriculture during this era:

*'...it (the Department of Agriculture) must also ensure that the results of such research are quickly made available so that they can be applied by farmers themselves. The rising generation of farmers must also be educated to meet the changing agricultural and economic situation and to appreciate promptly the practical outcome of the scientific investigations being carried out on their behalf'* (Spafford and Prescott 1946).

Van der Fliert (2003) described this process as single component extension, characterised by a one-way flow of information from the researcher to the extension officer to the farmer. Approximately 1 in 10 Australians were employed in agriculture during the 1950's; this was to later drop to 1 in 20 by the late 1970's (Garnaut and Lim-Applegate 1998).

### **2.1.2 Rural infrastructure and R, D&E capacity development period (1961 to 1975)**

Expanded rural communities were now receiving improved services and infrastructure (including water, electricity and roads). Significant expansion in the research undertaken by Departments of Agriculture and Universities was keeping pace with the needs of farmers. During this phase crop-pasture and crop-pasture-fallow rotations were becoming popularised as the importance of ley farming systems were becoming recognised (Aitchison 1966). Wide-scale clearance of native vegetation in soldier settlement developments continued to be a major task for rural communities.

The agribusiness network continued to expand through the established pastoral houses that serviced the livestock and wool markets. Retailing of agricultural inputs such as agricultural fertilisers and weedicides provided farmers with ready access to the simple technologies that resulted in significant productivity responses. The Transfer of Technology (ToT) model was gaining acceptance amongst research and extension professionals, largely because it was effective in transferring simple non-

complex technologies (King 2001). The provision of advice to farmers tended to be technically based due to rapid economic gains through productivity improvements (Campbell 1980).

### **2.1.3 Technology development and innovation period (1976 to 1990)**

Additional communication facilities were now being provided to rural communities, including telephone, radio and television. New on-farm technologies that were developed during this period included the direct drilling of crops, simple herbicide based weed control systems, and improved crop nutrition practices. The failure to apply integrated approaches to pest control were beginning to emerge as a major challenge for farmers, reflected through the on-set of pesticide resistance.

The size of farming operations were increasing, the result of a 'get big or get out' mentality. This led to increased farm debt, the result of farmers acquiring larger farm machinery and additional land purchases. The deregulation of the Australian finance sectors, the weakening in the value of the Australian dollar on world financial markets, interest rate increases spiked by high inflation and a deregulated grain marketing environment all had a major effect on the profitability and viability of farming. Downturn in rural communities accelerated the population drift to the larger regional centres, reductions in the provision of government services and the private sector rationalising regional services. The adoption of labour saving technologies had reduced the need to employ additional farm labour (Murdock et al. 1990). These factors contributed to a negative influence on many farming communities and rural towns. The rural crisis had now become a reality for many communities across South Australia.

Environmental concerns from over-clearing and poor farming practices were becoming an issue. The swing towards conservation farming practices were now gaining interest. Sustainable farming practices promoted through Landcare groups were gaining momentum, with increased support from

farming communities. Agriculture was beginning to be viewed from a systems perspective (Lawrence et al. 1992), with the traditional technology transfer model now being challenged.

Support for extension services was now reducing as State and Federal funding was being redirected to other areas of government priority. The SA Department of Agriculture now viewed mass media as a more cost-effective means of information dissemination (Campbell 1980) in comparison to traditional extension approaches involving the personal servicing of farmers.

#### **2.1.4 Improved business and farming systems period (1991 to 2005)**

This period was characterised by the withdrawal of traditional technology adoption approaches to extension services provided by government. Many State Departments of Agriculture were now focussing on what they considered to be areas of core business, regulation, quarantine and policy development.

Traditional extension roles were now being partially met by agribusiness input suppliers, farming systems based groups (supported largely by research and development corporations) and private consultants. The environment of extension delivery and management was undergoing rapid transformation, the result of changing government policy and an increasing role for the private sector. Governments, research and development corporations and farmer organisations were now calling for greater efficiency in technology adoption programs. Industry had now become more active in managing the technology adoption process as government support was withdrawn.

The concept of agricultural knowledge systems was embraced by industry stakeholders, in an effort to develop improved systems of information exchange and knowledge generation. This was considered to be in response to a void left by the departure of traditional extension services (Frank and Chamala 1992). This however had a positive influence in changing the role of State agencies

from that of disseminating information to one of a multi-transfer and exchange of information between all stakeholders in the knowledge system.

Many rural communities now having limited access to a wider range of communication facilities and mediums, though the 'digital divide' between rural and urban communities remained due to inequity in reliable access and availability.

Farming technologies and practices were now becoming even more complex, resulting in the need to examine more effective ways of transferring information and instigating change on-farm. The development and management of extension programs were beginning to encourage higher levels of farmer participation, resulting in the sharing of knowledge and in turn strengthening of information networks. Significant changes in information delivery through the recognition of structured farmer education programs and courses were characteristics of a rapidly changing environment. During this period Coutts (1997) believed that extension had succeeded in redefining itself in light of the trends of privatisation, user-pays systems and fewer agricultural enterprises.

Just as governments had rationalised their services, so too had the agribusiness sector. Agribusiness was now characterised by amalgamations and company take-overs, reduced research efforts, fewer staff in rural communities, and a greater reliance upon the servicing of customer needs through electronic means.

Farmer extension programs supported by government had now placed an emphasis upon building the personal and business capacity of the farm business. There was now a move toward one of creating self-reliance amongst farmers, as opposed to relying upon government handouts in times of drought or industry downturn. A number of nationally focused training and education programs

(including Property Management Planning and Farmbis) were successful in building self-reliance and resilience at the farm level (King 2001), though limited by uptake across farming communities.

The need to increase on-farm efficiencies in terms of managing the cost-price squeeze was evident. From the period 1955-56 to 1997-98, the net value of real farm production had fallen by 53% despite farm production having risen 170% and real gross farm production rising by 25%, a reflection of the rising costs of production and declining prices (in real terms) received for commodities. During this same period, commercial farms had declined at a rate of 1.3% per annum (Garnaut and Lim-Applegate 1998). It is evident that there was a strong decline in farmers' terms of trade (defined as the ratio of index of prices received by farmers to index of prices paid by farmers). In 1955-56 the farmers' terms of trade had a value of 225 units, by 1960-61 this was valued at 177 units, 1975-76 115 units, 1985-86 89 units, and 1997-98 83 units (ABARE 1998). The significance of agriculture in the Australian economy had now become far less, accounting for just 9% of total international trade (for the 5 years prior to June 2002) (Trewin 2005).

The number of farming properties in South Australia has declined significantly. In 1940-41 there were 10,980 commercial wheat farms (defined as those farms having 20 acres or more in land area under cultivation to wheat (Wilson 1946)), this had declined to 8,571 by 1955-56 (Carver 1960), but maintained this level to the mid seventies (8,522 in 1974-75 (Cameron 1977)). By 1996 the number of commercial farms involved in grain production was estimated at 6,485 (McLennan 1998) with a downward trend evident by 2005, with an estimate of 5739 farms (Trewin 2005).

### **2.1.5 Managing the social and environmental landscapes (2006 and beyond)**

Extension systems in Australian agriculture have matured, having gone through a transition phase from being described as basic technical information provision to one that encourages the formation of partnerships for developing new technologies, through empowerment of farmer driven groups

(Bimer et al. 2006). Based on current trends and emerging approaches to extension, there are a number of key elements that are likely to influence the direction of extension in Australia.

There is evidence of greater collaboration between industry research and development corporations. As an example, the Grain and Graze extension program aims to assist in providing on-farm research and learning opportunities for farmers involved in crop and livestock production. This program is supported by a collaborative funding arrangement from a number of organisations including the Grains Research and Development Corporation (GRDC), Meat and Livestock Australia (MLA), Australian Wool Innovation (AWI), The National Landcare Program (NLP), Land and Water Australia (LWA), State Departments of Agriculture, farming systems groups, Natural Resource Management (NRM) Boards and the private agribusiness sector (Stewart 2006).

Other approaches to extension delivery include community based social marketing that in effect involves a planned approach to the development of program delivery. Key attributes (as described by Jones (2005)) include a review of current knowledge and literature, focus group studies at the farmer level (to gain feedback on planned delivery approaches), implementation on a pilot basis, evaluation of practice change and finally review of approach and delivery strategies.

Information and communication technologies are developing at a rapid rate. There is the danger that if rural Australia does not embrace the tools and benefits from such technologies it is likely that the 'digital divide' between urban and rural communities will only broaden. Application of emerging technologies now presents farmers with highly specific analytical tools. Examples include precision agriculture and commercial applications of satellite derived crop-monitoring tools. Increasingly through availability of the Internet, farmers, industry and rural communities are accessing information electronically. Fee based 'one to one' servicing has now reluctantly been accepted by farmers.

Governments are now experimenting with extension approaches that are based on behavioural change, in an effort to identify and address local needs and opportunities. Governments are now applying a strategic approach to delivering specified projects with demonstrated outcomes. The void left by the withdrawal of technically focussed services are in some instances partially being met by agribusiness resellers. Innovative farmers however are cautious, largely due to the recognition of the value of independent and unbiased information sourced from credible providers (Stone 2005).

It is likely that there will be additional pressures on the farming systems, with farmers themselves having to justify their right to farm from an environmental perspective. In response to this, farmers will need to consider the adoption of environmental management systems and quality assurance programs in order to manage the farming environment. Issues in relation to climate variability and change, the role of genetically modified organisms, carbon trading issues, competition for rural land from encroaching urban communities add to external pressures faced by farmers.

## **2.2 EXTENSION SYSTEMS AND CHANGE**

Agricultural extension plays an important role in the development and improvement of agricultural systems worldwide, and traditionally it has been considered that the provision of services has been the responsibility of government (Kidd et al. 2000). State governments themselves have difficulty in agreeing to a common definition or approach, with a shift towards the delivery of outcome orientated services having a 'triple bottom line' approach (addressing the elements of political, economic and social consequences) common to most agencies (Marsh 1997). The perception that government is the sole provider of services is changing, as servicing is reduced due to competing demands in other sectors of government responsibility. The role of extension is being redefined as more stakeholders become involved in delivering extension programs. Extension is about creating positive change on farm, involving a process of facilitated learning and change within rural communities (Fulton et al. 2003). Extension is also development based and reliant upon the active involvement of people (Duvel 1995), with communication central to a formal intervention process (Watts 1984).

**TABLE 2.1: Summary of developments associated with the Australian dryland agricultural environment (1945 to present)**

Period of development	Development, infrastructure and economy	Research, development and extension	Technology development	Agribusiness development	On-farm implications for farmers
Post-war agricultural land development (1945 to 1960)	Soldier settler block developments Formation of the Australian Wheat Board (to assist in stabilisation of wheat prices) Government incentives and support to agricultural development 80% of Australia's export earnings derived from agriculture Limited rural services and infrastructure	CSIRO and State Government Departments of Agriculture develop their infrastructure and research capacities and capabilities Extension services focus on soldier resettlement support Training of research and extension officers considered a government priority	Agricultural expansion, increased mechanisation Introduction of herbicides for weed control (2,4-D) Addition of trace elements to fertilisers result in major expansion in pasture area Horses replaced by machinery Rabbits become an environmental concern	Local service centres established / expanded for farming community, linked to fertiliser supplies, sale of sheep and wool products	Technology was providing simple 'quick-fix' solutions to farmer problems. Technology was viewed as being 'good' and simple to use.
Rural infrastructure and R, D&E capacity development (1961 to 1975)	Development of infrastructure for communities (water, power, roads) Broad scale land clearing and development, supported by increased capacity of machinery Re-focus of exports away from UK to the Pacific rim.	Significant expansion in Australia's research capacity and institutional development Government extension systems developed for the farmer	Introduction of herbicides Continued expansion in pasture area, total area now exceeding that of fallow and crop area Lucerne industry developed	Agribusiness services and networks established across rural Australia, profitable times for Australia's 'pastoral houses' Bulk handling of grain and fertilizer introduced	Agricultural technology being viewed as 'good for farmers to embrace' Technology making farming easier, reduced emphasis upon elements of physical labour
Technology development and innovation (1976 to 1990)	Development of communication systems and services to communities (phone services progressing from shared 'party lines' to 'subscriber trunk dialling' STD telephone services) Deregulation Aust. finance sector Economy suffering due to high interest rates, many farming businesses collapse and farmers walk off farms Significant rationalisation amongst rural communities, loss of services, farm size increase	New technologies developed, including direct drilling systems Increased reliance upon herbicides, introduction of chemical fallowing Varietal improvement, particularly disease resistance of major benefit to farmers	Lucerne pastures devastated through introduction of aphids Grassy weeds become major problem in crops and pasture systems Invasive plant species providing challenges for researchers and farmers (skeleton weed, brome grass, wild oats)	Significant investment into agricultural input industries, with on-farm R&D by industry companies taking place Agribusiness playing a greater role in extension and communication Live-sheep exports to the Middle-east continue to expand	Increased machinery size & capacity, 'get big or get out' Increased interest rates major issue for the survival of farm businesses Varietal improvement, particularly disease resistance of major benefit to farmers Environmental concerns relating to land management (soil erosion, mechanical fallowing become real issues for farmers to manage)

**TABLE 2.1: Summary of developments associated with the Australian dryland agricultural environment (continued)**

Period of development	Development, infrastructure and economy	Research, development and extension	Technology development	Agribusiness development	On-farm implications for farmers
Improved business and farming systems (1991 to 2005)	<p>Re-focussing of post-farm gate value-adding opportunities                      Community pressure in relation to animal welfare, live-sheep exports                      Environmental concerns shared across the community                      Development of the 'technical information age'                      On-set of the 'digital divide' between city and rural communities, for example access to reliable internet services</p>	<p>Development of 'self-reliance' and risk management / capacity building amongst farmers                      Environmental issues (salinity, land degradation) addressed by Landcare movement,                      Attitude change in favour of developing sustainable agricultural systems                      Govt. extension reduced, main emphasis policy and regulation</p>	<p>Genetically Modified Organisms (GMO's) provide debate in urban and rural communities,                      Development of Environmental Management Systems (EMS) and Quality Assurance (QA)                      Climate change emerging issue for farmers and communities                      Electronic technologies such as yield mapping, precision agriculture, Global Positioning Systems (GPS) popularised</p>	<p>Rationalisation agribusiness companies and boards                      Release of generic pesticides result in cheaper products for farmers, but reduces company profitability                      Collapse of wool industry                      Agribusiness and consultants partially fulfil extension void left by withdrawal of services                      Tripling of overseas agricultural exports since the 1970's (Productivity Commission, 2005).</p>	<p>Increased cropping intensities,                      Deregulation of grain markets result in World price fluctuations a constant reality with grain prices received equal to cost of production                      Increased reliance upon consultants                      Farm groups become more pro-active in sharing ideas, information and experience                      In the 20 years to 2002-03, the number of family farms in Australia fell 25%</p>
Managing the social and environmental landscapes; (2006 and beyond)	<p>Government agencies focussed on sustainable agricultural development, integration of natural resource management, project based delivery, development and enforcement of policy.                      Extension services continue to be contracted out to private and government providers.                      Farmers' 'terms of trade' continues to decline.                      New opportunities for farmers in relation to bio-diesel as an alternate fuel source</p>	<p>Increasing emphasis upon social research and marketing approach to identifying end-user needs                      Continued pressures in relation to acquisition of funding to support agricultural research, development and extension</p>	<p>Web based electronic information access becomes a fact of life, due to the cost-effectiveness from a provider sense.                      Technology is providing farmers with increased ability to monitor farm, crop and livestock enterprises</p>	<p>Rationalisation of agribusiness services and company structures continue.                      One to one services delivered on-farm cost recovery basis                      Agribusiness having increasing investments into plant breeding and seed technology                      Loss of independently focussed information to farmers</p>	<p>Development of a truly integrated natural resource and production management based system                      Farmer skills being enhanced through pro-active involvement in programs.                      Continued pressures to remain economically viable, requiring higher production outputs and farm size to achieve profitability</p>

### **2.2.1 Changes in extension delivery by government**

Previously governments viewed extension as a public good, but in recent years competitive needs for funding programs has driven an attitude change by governments. According to Dinar (1996) governments now believe extension should be demand driven, often resulting in extension agencies delineating between their public and private good functions. Marsh (1997) describes private good information as being individually tailored and valued within a local region or single farming enterprise. Governments themselves have redirected funding to areas of perceived social need such as health, education and law enforcement at the expense of extension service delivery.

In some instances this has highlighted the incidence of market failure where governments have withdrawn extension services in an environment where the private sector has been found to have little if any extension role at all. Market failure occurs where the private sector does not adequately meet farmer demand in the provision of extension services (Hayami 1974). The definition of what is public and private good is open to broad interpretation. Whilst government agencies maintain some commitment to servicing public good activities, it is generally only in areas of market failure where support is likely to occur if at all.

In many situations governments have adopted either the private contracting or commercialisation of extension services in an effort to reduce the dependency of public funding. In adopting this approach public funds have generally been used for engaging the private sector to deliver specified outcomes (Rivera and Alex 2006) with minimal returns to government. There has been considerable debate over the profitability and efficiencies of commercialisation of services particularly within government.

The commercialisation of services has impacted on the effectiveness of the extension process and the dynamics of change around the world. Commercialisation of extension services has in many

instances led to an inequity in the ability of farmers to access services, as is the case in New Zealand (Rivera 1993) and Britain (Bentz 1993). The commercialisation of extension services has led to reduced contact at the farmer level, an experience shared first in the early 1980's in Tasmania (Bloome 1992), the UK (Bentz 1993) and New Zealand (Rivera 1993). This has been found to have a negative influence on the development of innovation systems (Morriss et al. 2006) and agricultural knowledge and information systems (Proost and Roling 1992). The commercialisation of extension services has been of a mixed success for governments with no one approach being recognised as a successful model for other agencies to assimilate.

Extension delivery continues to undergo significant change, and is characterised by a shift in emphasis to one of building social capital of rural communities (Coutts et al. 2005), service reduction, commercialisation and privatisation (Rivera and Cary 1995, Vanclay and Lawrence 1995). Extension agencies have undergone significant downsizing in their service provision role (Cary and Wilkinson 1995), with Federal Government initiatives targeting industry self-reliance by supporting private sector delivery (Scott 1997). As non-agricultural industries out-perform agriculture, government support to extension has reduced (Wells 1994) affecting the ability of rural communities and producers to access services. Hightower (1991) believes that farmers have continued to seek neutral and unbiased information and understanding in relation to complex technologies, resulting in increased pressures on current extension services, often resulting in increased inefficiencies and inability to cope with demand.

The demise of public funded extension services is having a detrimental impact on extension agencies themselves. Studies by Rose (1996) revealed that state agency officers were concerned about the conflict in information provision between private and public extension providers and a reduced appreciation of the role of extension. The roles of extension agencies and their officers are changing. There has been a failure to clearly define the role and functions of those involved in

delivery, a reflection of poor communication both within and between organisations. Beckingsdale (1997) is critical of change in emphasis of extension service delivery by extension organisations, with agencies having adopted a stronger economic focus as opposed to farming systems development. In many instances there has been little regard for identifying and meeting farmer needs, with an underlying assumption that farmers are willing recipients of all information (Lafin 1983).

Whilst in many situations there has been reluctance by extension officers to accept change in the field, traditional farmer needs have not been fully explored or appreciated. It could be argued that the needs of farming communities are becoming of secondary importance to the goals and functions of government agencies. Many agencies are now considered to focus on economic development, through encouraging the formation of new industries and value adding, whilst reducing support to those industries considered mature. The private sector has in many instances failed to take up those services that the public sector has departed from.

It is evident that the reduction, commercialisation and privatisation of extension services have had a significant impact on the delivery of services to communities and industry groups. Issues relating to equity in access, the government placing their own agenda ahead of farmer needs and opportunities reflect the loss in recognition and professionalism that the science of extension deserves. This has and will continue to have a negative impact on change at the farm level, and presents additional challenges to those who are involved in developing improved systems of extension on-farm.

### **2.2.2 Traditional approaches to extension**

The environment in which new technology is being delivered is characterised by rapid change. To suggest that technology is delivered to farmers based on information provision may be indicative of a traditional paradigm within which scientists and extension officers have operated. During the 1990's traditional extension paradigms viewed the extension officer as being the source of information and

practice change (Cowan 1997, Cornwell et al. 1994). This model held the extension officer or researcher in a powerful position, viewed as the primary source of new knowledge (Scoones and Thompson 1994, Vanclay and Lawrence 1995) that has been presented as a top-down approach (Foster et al. 1995). Conventional approaches to extension have been based on a set of common assumptions that limit ability to deal with complex and changing realities (Cornwell et al. 1994, Arnon 1989). More often than not technology has been extended to farmers in a piece-meal fashion with little allowance given to the complexities associated with farming systems, with technology adoption viewed as socially desirable, and those farmers failing to adopt viewed as laggards (Frank 1995a). The traditional technology transfer model has dismissed local complexity. Technologies successful in one environment have been applied to other situations irrespective of the local context, often resulting in (Pretty and Chambers 1994). This is not surprising as local adaptations of technologies are often considered necessary to achieve adoption (Jarrett 1982).

Extension methodologies are changing out of necessity to address past failures. Extension is progressing from the traditional technology transfer model of information provision to one of supporting farmers to be the experts in managing complex knowledge systems (Roling and Jiggins 1995). This has resulted in the acquisition of critical thinking skills by the farmer in an environment that is conducive for group facilitation (Duvel 1995).

Extension is now described as a process of engagement through groups, communities and individuals. This approach has enabled farmers to deal with the issues that have affected them, and identify solutions as to how best they may wish to progress (Coutts et al. 2005). Government agencies and organisations are increasingly forming partnerships with communities, industries and research and development corporations (Lambert and Elix 2003), largely supported by Federal Government initiatives.

It is also evident that extension is now being directed towards communities as opposed to individuals. Solutions to problems are now generated from the experience and pooling of knowledge within a well supported group environment. Extension delivery is now progressing towards greater market responsiveness with a range of initiatives developed by different organisations and institutions that are described below.

### **2.2.3 The farmer driven approach**

Only recently has the concept of farmer driven extension been formally recognised. Farmers are no longer viewed as passive recipients of knowledge but as developers of new systems. In the past the development of extension programs lacked practical relevance. According to Coutts (1997) this was due to minimal producer involvement in program development. There are now many examples of successful farmer driven programs that have been developed within rural communities that have focussed on local needs in an effort to accelerate the rate of adoption. Examples include TopCrop (Wagner 1990) and Producer Initiated Research and Development Sites (PIRDS) (Stephens 1997). These programs have been successful in bringing together a wide range of experience and knowledge (Franzluebbers and Francis, 1991) with farmers managing the process.

This group approach provides participants with the opportunity to learn from others by encouraging interaction between participants (Coutts 1997). Benefits identified by farmers involved in these programs include the ability to exchange ideas between group members leading to increased productivity (Ashton 1995), with technologies extended in an appropriate format at the farm level (Ashby 1996).

The problem solving skills of farmers can be developed through utilising farmer experiences within local knowledge systems (Frank and Chamala 1992). This approach has recognised that farmers have sound local knowledge and there are valid reasons for their behaviour (Beets 1996). Arnon

(1989) considered it important farmers to have been involved at all stages of knowledge acquisition, taking into consideration the social, economic and institutional constraints in this process. Learning through active participation has allowed farmers the opportunity to adapt practices to suit local needs (Green et al. 1993), with farmers leading the problem solving process (Oakley 1988).

#### **2.2.4 Farming systems development**

The concept of farming systems development was formally recognised during the 1970's, with the approach only being applied formally through research and development corporation supported projects in Australia since the early 1990's (Zamani 2003). Adoption of new technology often failed due to the lack of appreciation of the farming system. Adoption was found to be more successful when introduced within the context of a complete farming system. Hildebrand (1990) described a farming system as a set of enterprises and activities developed in line with the available resources of a farming business. The management of the farming system is considered complex, requiring highly developed skills, flexibility, ingenuity and attention to detail (Hassanein and Kloppenburg 1995).

Failure to recognise complexities of the farming system has led to significant failures with the adoption of a number of technological innovations in recent years. The failure to adopt direct drilling systems in the 1970's was characterised by farmer inexperience in chemical use, inadequate machinery for handling high levels of plant residue and increase in cereal root diseases. In effect there was the failure to consider all of the interacting factors within the context of a farming system. The promotion of grass free farming during the 1980's accelerated its own set of problems, including the on-set of herbicide resistance and animal health issues in relation to sheep grazing legume dominant pastures. As a result it has become apparent that any technology should be viewed as part of a dynamic and interacting system. Stern (1979) believed that success of a farming system was reflected through the ability of farmers to adopt the system, maintain productivity of the land and optimise economic viability.

The key to the success of farming systems research is the fact that the approach is farmer-driven rather than being directed by the needs of the researcher (Watts 1984). According to Walker et al. (1997) the farming systems approach requires effective integration of knowledge from a range of sources and activities. The adoption of a farmer driven ethos towards extension has originated from the concept of farming systems research and extension, actively involving farmers in research and evaluation on-farm using valid experimental approaches (Weust et al. 1995).

Critical to developing the confidence by farmers to implement changes on-farm is the need to ensure social inclusion, recognition and support processes amongst farmers (Nicholson et al. 2003). Since the information is derived and developed locally it is found to have more direct relevance to local farming systems and in turn is more highly valued by farmers. On-farm testing approaches are a key component of farming systems development, providing a practical environment that farmers prefer to learn and operate.

A key element of farming systems research has been farmer driven and owned demonstrations (Barao 1992). This leads to the transfer and application of the specific knowledge that provides an opportunity to strengthen the confidence of farmers in their own environment, leading to higher levels of adoption (Hagmann et al. 1996).

### **2.2.5 Building the capacity of individuals and communities**

Capacity building can be described as a process designed to help groups or individuals manage their changing environment or circumstances through improving a range of skills and competencies that relate to human, financial, physical and natural capital (Macadam et al. 2004).

The reliance upon extension providing answers or telling farmers what to do is diminishing at a rapid rate (Holmes 2003). Extension agencies in many instances are now focussing on the key elements

associated with capacity building, as is illustrated by the following descriptor of services provided by the Victorian Department of Primary Industries (in describing their extension role):

*'...influencing the decision making of land managers with the intention of achieving balanced outcomes for the Victorian economy, the environment and for the social good of the local community' (May et al. 2003).*

It is evident that change is constant in relation to the provision of extension services by different organisations be they government, university or privately owned organisations. The changing agricultural environment post-war in Australia has been characterised by a range of different approaches, needs and priorities. This has altered according to the stage of development of the country and agriculture, and is reflective of policy and public attitude at the time.

This has had a significant impact on the farming community and the development of farming systems. Farmers themselves have been influenced by the changes that have occurred, often with mixed messages as governments have changed their policy from one of support and development for agriculture (creating elements of dependency) through to one of creating self-directed learning and independence. Older farmers for example have gone from operating in an extension environment for which they have become dependent upon research and extension providing them with the answers through to the current environment in which the extension emphasis has largely been based upon building personal capacity and capability. This has created elements of confusion and mixed messages, particularly for older farmers who have operated across a number of significant phases of agricultural development (Table 2.1). For many farmers, there has been a reluctance to be involved in group based extension programs.

In this environment of change extension itself is faced with immense challenges to find its own identity and role in this complex change process. Through gaining better understanding of these

complexities, it will be possible to develop strategies that help to improve extension processes in a resource limited environment, a key outcome addressed in this thesis.

## **2.3 THE NATURE OF ADOPTION**

Changes in the extension environment are having an influence over the nature and characteristics associated with adoption processes. In order to fully understand the change process, it is essential that an appreciation of the nature and characteristics associated with the environment and technology is generated, in addition to developing an understanding of the socio-economic characteristics that influence decision-making processes. Whilst much research has been devoted to identifying factors that influence adoption, few studies have examined the relationships between the intervening variables as has been the approach taken in this study.

### **2.3.1 Developing an understanding of adoption**

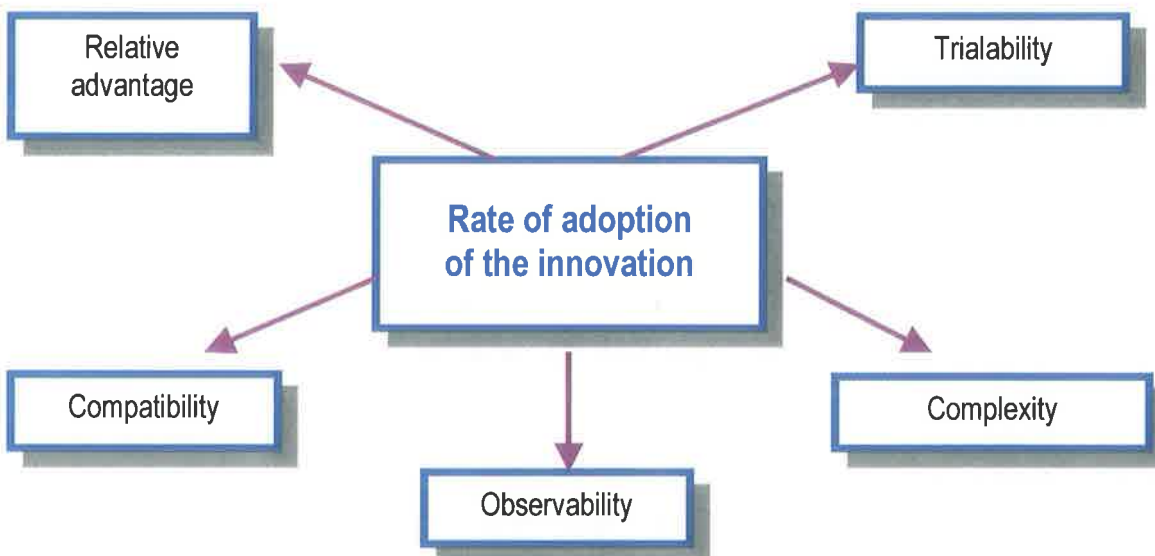
There are many definitions available in relation to adoption. In its simplest form adoption can be best described as a continuous process involving the creation of awareness, interest, evaluation, experimentation and adoption (Bootha 1986) rather than one having discrete outcomes (Cary et al. 2002). Adoption is also considered to involve learning processes achieved through knowledge acquisition (Lindner 1986), with the decision to adopt by farmers being based upon a risk assessment procedure. The adoption process is not necessarily an automatic response by farmers to a new technology or idea, but is influenced by a number of complex factors.

There have been a large number of studies conducted aimed at developing a better understanding of the processes and behaviour that lead to adoption. Perhaps the work that has the greatest impact on understanding the adoption process is the work of Rogers (1995) who initially conducted studies relating to the adoption of hybrid corn varieties and the herbicide 2,4D amongst American farmers in the 1950's. A number of key characteristics associated with the innovation (as presented in Figure

2.1) were considered to influence the rate of adoption. These were the relative advantage (associated with the technology), trialability (ability to experiment and evaluate), observability (to clearly identify the net advantages and results), the relative complexity and compatibility (the ease at which the innovation can be integrated into the farming system).

Much of this early work still forms the basis of much of the adoption and diffusion theory that exists today. It is not only applied to agriculture but also across industry and the wider community in general. Whilst this work has been held in high regard for its logical framework, it was developed during an era when technologies relating to agriculture were relatively simple and effective, with the primary extension model described as the transfer of technology (ToT) model.

**FIGURE 2.1: Characteristics associated with innovation that influence the rate of adoption (after Rogers 1995)**



### 2.3.2 Describing key elements influencing adoption

The question arises as to whether or not Rogers' model is still relevant today and to what degree the model accounts for additional personal and situational characteristics associated with the extension environment. An examination of this model will assist in addressing this question. The key elements are discussed in further detail in the following text.

### **2.3.2.1 Relative Advantage**

The relative advantage refers to the ability of the technology or practice to offer specific advantages over current practices and may be financial or intrinsic (of personal benefit) in nature. Rogers (1995) defined relative advantage as the degree to which an innovation is perceived to be better than the idea it supersedes. Technologies that offer short-term benefits are likely to be adopted more rapidly than those technologies in which the benefits are realised in the longer term (Tenge et al. 2004).

### **2.3.2.2 Trialability**

Trialability refers to the ability of the farmer to actually experiment with the practice and evaluate it within the context of his/her own farming environment (Rogers 1995). This forms part of the adaptation process for the particular technology. Farmers being able to observe at first hand the nature and impact of the technology will adopt at a faster rate (Cary et al. 2001).

### **2.3.2.3 Complexity**

Complexity can be described as the degree to which the practice is considered too complex to understand (Rogers 1995) and influences the decision-making processes leading to adoption (Kaine and Beswell 2002). Practices that are rated low in complexity and high in their compatibility tend to be adopted more rapidly by farmers (Fliegel and Kivlin 1962, Ennew et al. 1992).

### **2.3.2.4 Observability**

Observability can be defined as the degree to which the results of an innovation are visible to others (Rogers 1995). For many farmers having the ability to observe new practices first hand is likely to lead to higher levels of adoption. In order for farmers to comprehend the technology they need ready access to information, so that adoption can take place (Guerin and Guerin 1994). Adoption is unlikely to occur until the farmer uses the innovation on a trial basis (Fisher et al. 1996), or when farmers can see and examine the attributes of a particular technology through participatory means (Hobbs and Gupta 2003).

### **2.3.2.5 Compatibility**

Compatibility relates to the extent to which a new practice can be integrated into existing farming systems (Cary et al. 2001) and needs to be viewed from the perspective of the farmer within the context of a social system (Rogers 1995). This requires knowledge of the interacting variables that influence the adoption of the technology.

Whilst the adoption model provides a useful means of describing the factors that influence adoption, the theory behind the diffusion process as developed by Rogers (whilst still relevant today) has been expanded further, taking into consideration socio-economic characteristics associated with adoption.

### **2.3.3 The diffusion of innovations**

The diffusion of innovations is considered part of a broader social change process (Rogers et al. 1988, Roling and Jiggins 1995) and is considered socially desirable (Goss 1979) involving interpersonal communication networks that assist in the flow of information (Hildebrand 1988).

The adoption process is part of a social system and Rogers (1995) has described the adoption-diffusion path as a sigmoid (s-shaped) curve. When the technology is first released, only a few farmers adopt the practice (these farmers are described as the 'innovators'). As time progresses more adopt the technology ('early majority') followed by others (described as the 'late majority' adopters). Eventually the number of potential adopters decreases (the last category of potential adopters being described as 'laggards', who may not necessarily adopt) causing the rate of adoption to decrease, to a point where adoption ceases altogether. Although the innovators are first to adopt, Rogers (1995) believe that they are virtually excluded from the social system and play a limited role in the diffusion of the innovation. Their exclusion is the result of social pressures exerted by the wider farming community. Local opinion leaders are considered to be most influential in the change process, as they are seen to have personal characteristics common to the broader social system.

This approach by Rogers fails to realise that farmers may be innovators in one area of discipline and so-called laggards in other areas of technical competency (Frank 1995b). There is the danger of stereotyping farmers for what they are not through applying theoretical concepts to real life situations. It is necessary that a better understanding is developed in relation to the reasons for adoption and non-adoption by gaining a better insight into the decision-making processes undertaken by farmers in what is characterised by a complex environment of intervention.

There are also a number of additional factors that influence the characteristics and nature of adoption that are complex in nature. Some of these factors are described below.

The categorisation of farmers according to their adoptive behaviour does not take into consideration the practical reasons for non-adoption, which may be the result of a genuine need not being fulfilled (Foster et al. 1995). There has also been an underlying assumption by advisers that technology adoption is socially desirable behaviour and farmers should all adopt the practices that are being adopted (Frank 1995b). Many extension officers failing to fully appreciate farmer knowledge and experience and need to develop a better understanding of the farmer's own particular point of view regarding non-adoption (Vanclay 1992). It is evident that there are a large number of interacting factors that impact on the adoption process, with many of these linked to the exchange of information and generation of knowledge within the agricultural system. Rogers' adoption and diffusion models provide a simplistic means of viewing the adoption process, however fail to consider the full complexities and nature of adoption decisions that farmers nowadays are faced with. As a result it is necessary to examine more closely the complexities associated with the environment of decision-making, which includes the nature of the agricultural knowledge system, and the personal and situational factors that influence farmer behaviour and in turn the change process.

#### **2.3.4 Time lag to adoption**

Adoption does not occur automatically, but occurs over a period of time. The time taken in relation to the adoption of innovations varies considerably (van den Ban and Hawkins 1988) and is referred to as the 'time lag to adoption'. The time lag to adoption can be defined as the time from when farmers first hear about a new innovation until the time that they first adopt it (Fischer et al. 1996), and it may be influenced by distance that farmers are from the information source (Lindner et al. 1982), or the ability of the farmer to seek out information (Noonan and Gorddard 1994). The ability of farmers to manage information, and the context in which the information is viewed will also influence the speed at which innovations are adopted (Dillman 1985).

#### **2.3.5 Sequential adoption patterns**

The sequential adoption of technologies was formally proposed in the early 1970's, within the context of adoption of technologies relating to the development of agricultural properties (Crouch 1972). Crouch considered that the adoption of succeeding practices was in many instances dependent upon the prior adoption of others, with certain practices occurred in clusters, referred to as a process of cluster adoption. This led to the concept of a systems approach to adoption. The net effect from a systems perspective was that as each practice was adopted, farmers would then go through a review and evaluation process associated with each step of adoption (Hanson et al. 1995) in addition to reviewing the information received within a broader systems perspective (Fischer et al. 1996). It is evident that farmers do adopt farming practices in sequences, and may well be linked to the stage of property development as well (Frank 1995a). In many instances this notion is not fully appreciated by those who work in extension roles, in that technologies are often promoted in 'piece meal fashion', where those promoting the technology fail to fully appreciate the nature and interaction between enterprises and production systems across the farm business.

## **2.4 AGRICULTURAL KNOWLEDGE SYSTEMS**

The ability for farmers to adopt new technology is influenced by the characteristics associated with the agricultural knowledge system, with information provision and sharing central to the generation of new ideas, knowledge and in turn change. This section provides an overview of the characteristics associated with agricultural knowledge systems and broader issues relating to the communication and transfer of information within rural communities.

### **2.4.1 Characteristics associated with the agricultural knowledge system**

A knowledge system can be defined as a social process involving interactive communication between stakeholders in a system (Blum 1995) that leads towards informed decision-making (Engel and van den Bor 1995, Wu and Pretty 2004). The characteristics of the system in terms of openness, integration, diversity and linkages will influence diffusion of innovations (King 1995). A knowledge system is considered cyclical in nature and is characterised by six basic functions. These are problem identification (at the farmer level); innovation generation; validation (under farmers' conditions); dissemination; utilisation and evaluation (Arnon 1989). Knowledge systems comprise a multiplicity of actors and networks (Scoones and Thompson 1994) and provide a means of communicating technical and social information with knowledge emerging as a result of this interaction. Information is disseminated and opinions influenced by participants (Bunting 1992). The information within the system has a political dimension characterised by who provides the interpretation and who influences information flows (Scoones and Thompson 1994). Through examining networks and information exchanges it is possible to consider both social and power relationships.

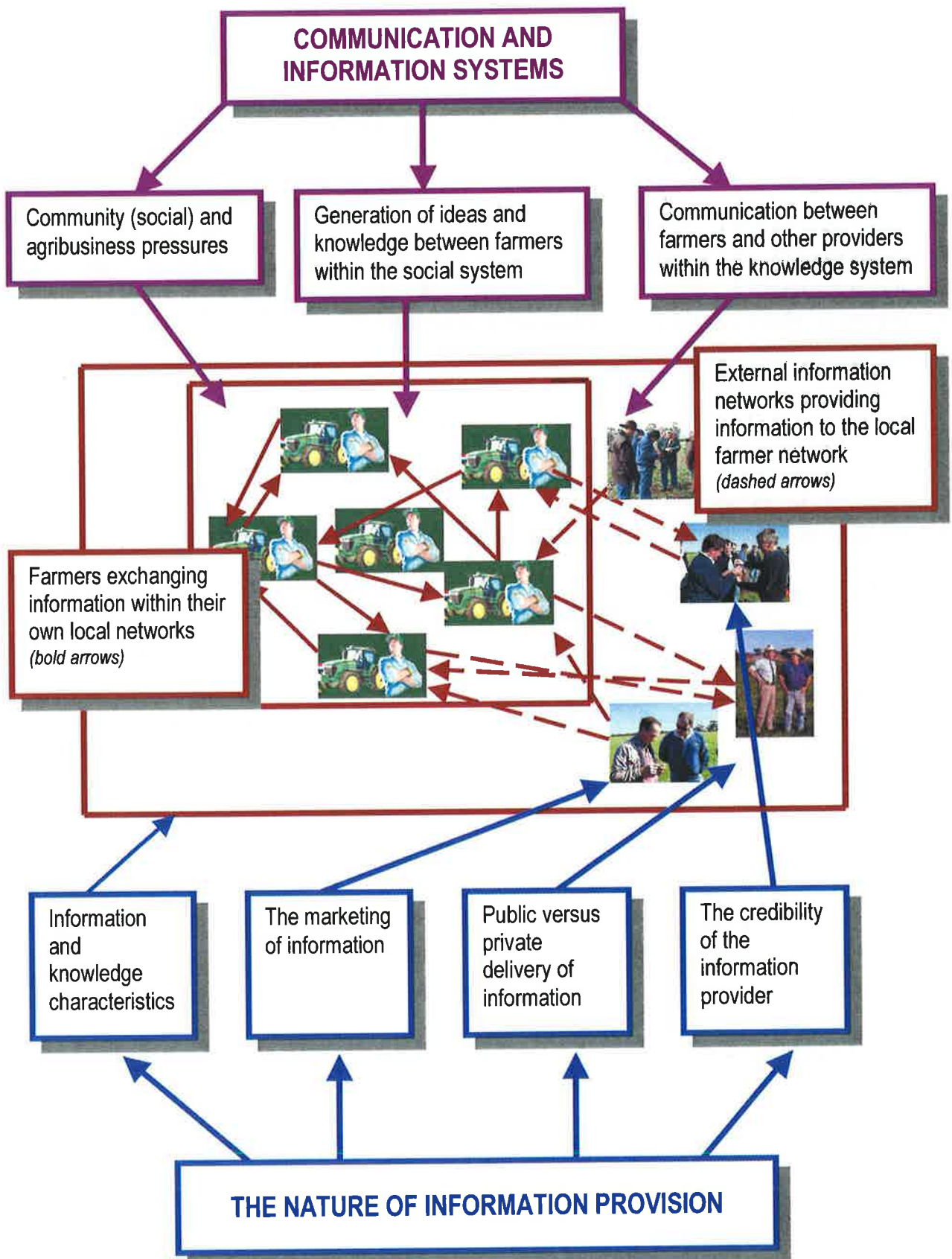
It could be argued that those extension officers involved in the delivery of information and technology have been active participants in knowledge systems for many years without necessarily realising their involvement. Extension organisations in recent years have been involved in the wholesaling

information to a wide audience of intermediary service providers. The skills of all providers in the knowledge system have been enhanced, resulting in a demand driven rather than a science-push approach. Roling and Jiggins (1995) describe the ideal knowledge system as one that facilitates the rapid adoption of technological innovations from researcher to farmer.

The real issue may not be about describing a knowledge system but recognising communication networks and linkages already in place in rural communities, a characteristic that has not been explored to any significant extent in adoption studies. Through focussing on the interactions between the stakeholders in the knowledge system there is the opportunity to improve the efficiency of the communication network, leading to clear and consistent messages and appropriate feedback mechanisms to all in the system. In order for knowledge systems to be relevant and effective it is critical for farmers to independently view the information from a range of perspectives (Hassanein and Kloppenburg 1995). Knowledge will be more acceptable if the farmers themselves are involved in the generation of that knowledge (Eshuis and Stuver 2005), thus ensuring knowledge is practical in nature and relevant to local farming systems.

Knowledge systems can also have their negative impact on the uptake of new practices due to social pressures and norms. This can create an unwillingness to adopt practices that are considered to be alternative within a community (Burton et al. 2003). For knowledge systems to be effective they must be responsive to change. If this is achieved, Rivera et al. (2005) believe that adoption decisions will be better informed and within the context most appropriate to the farmer. An overview of the characteristics associated with an agricultural knowledge system is presented in a conceptual model (Figure 2.2). Elements of the model include the nature and context of the information provision (in terms of addressing the characteristics of the information and knowledge), credibility of the information provider, and different approaches to the provision of information from public and private sectors.

**FIGURE 2.2: An overview of the characteristics associated with an agricultural knowledge system**



### **2.4.2 Characteristics of knowledge**

It is important that we have an understanding of the relationships between information provision and the generation of knowledge. This will assist in providing a better understanding of the significance of a knowledge system and those factors (external and internal) that influence information flows and in turn behavioural change. There is an over abundance of information that is available within agricultural knowledge systems. The question arises as to how can farmers and other stakeholders within the knowledge system effectively manage such information. The first important step is to develop a better understanding of the nature of information and knowledge and the characteristics associated with information flows.

Knowledge is considered a social construct, developed and modified by an individual's experiences and interactions within a social environment (Long and Villareal 1994, Cornwell et al. 1994) and is controlled and generated by different people in a community (Scoones and Thompson 1994). Knowledge assists in critical thinking, and the ability to make better decisions within agricultural systems (Feder et al. 2004, Kloppenburg 1991).

Knowledge consists of information, concepts, techniques and skills. These are stored, improved, developed, disseminated and applied within a knowledge system (Bunting 1992). Knowledge is transferred through communication as part of a locally driven knowledge system (Okali et al. 1994, Steel 1996), and is the product of information and experiences.

### **2.4.3 Information characteristics within a knowledge system**

Central to the functioning of an agricultural knowledge system is the provision and exchange of information. Often the provision of information has been undervalued and the link to making informed decisions not fully appreciated (Schnitkey et al. 1992). The ability to access information is considered an essential factor in farmers being able to evaluate new technology, having a direct

influence over adoption (Diederer et al. 2003, Anderson 1993), and is considered to be critical to the success of any farming operation (Howard and MacMillan 1991). Farmers are now considered active gatherers of information, motivated by prospects of increased economic returns (Feder and Slade 1984). This is contrary to traditional extension beliefs that suggested farmers were passive receivers of information. This concept reinforces the importance of needs analysis and an understanding of what drives farmers towards information acquisition.

The onset of information communication technologies, the Internet, direct marketing and the perceived value of information is having a profound effect on information flow within knowledge systems. How farmers manage, synthesise and utilise information and knowledge will depend on their own skills in identifying information that is most relevant to their own farming situation. There is the need to consider the quality and format in which information is disseminated within a knowledge system (Lyster and Bauer 1995), with a range of different sources and formats considered the best approach in order to cater for different farmer preferences (Eshuis and Stuvier 2005).

#### **2.4.4 Communication networks and delivery mechanisms**

Critical to the process of acquiring information is the process of communication, with the adoption process influenced by sound communication skills (Cowan 1997). There are numerous channels of communication available for those wishing to introduce change. The process of communication is necessary in order to gain new ideas, information and knowledge in relation to the farming environment or technological change. The more efficient and effective the communication process, the greater is the opportunity for reviewing and introducing change. Knowledge once gained is then used to actively make a decision about whether change in behaviour will take place (Fleigel 1984).

Blum (1991) and Westermarck (1981) consider that farmers are the most important and valued sources of information for other farmers as not all have access to extension agents. It is considered

that the sharing of information amongst farming peers as being considered critical in the adoption process (Nicholson et al. 2003). Westermarck (1981) found that the ability of farmers to be socially integrated in their own system and the level of respect that they command amongst peers influenced the communication process. The process of mapping communication lines between different individuals within a given social system can act as a useful means of identifying the dominant providers of information. According to Rogers (1995) this is termed social diffusion research and is one means of identifying the most influential information providers within a knowledge system.

The environment and situation in which new technology and extension messages are delivered influences adoption. Harper et al. (1990) found that where extension programs incorporated field days in the methodology, adoption rates increased. Noonan and Gordard (1994) found that wheat growers placed more credibility on local trials and field day information than when compared to information derived from trials and field days external to their local farming environment. Richardson and Mustian (1995) identified personal visits, meetings, newsletters, demonstrations and workshops to be the most preferred delivery methods by farmers.

Information needs to be received in an understandable format (Richardson and Mustian, 1995) in a manner that is timely, relevant, and frequent (Laffin 1983). This is supported through the experiences of the delivery of soil conservation practices through Landcare groups (Nelson and Mues, 1993). It is apparent that information delivered must be timely, precise and relevant. The particular delivery mechanisms used must be appropriate to the particular environment, nature of the technology and characteristics of the target audience.

#### **2.4.5 Credibility and the provision of information**

The efficiency at which information is transferred in a system is often reflective upon the credibility of the source. The provision of information is considered to impact greatest where there are high

elements of credibility associated with that information source, such as consultants (Winter and May 2001), government organisations, adult educators and other farmers (Breuning 1993).

It is considered that farmers should avoid becoming too reliant on single sources of information, but instead utilise multiple sources. Howard and MacMillan (1991) found that successful farmers made use of multiple information sources often seeking a second opinion from other independent sources. These include farmers themselves (Foltz et al. 1996), agricultural bankers (Patrick and Ullerich, 1996), and stock and station agents (Riethmuller 1978). Dependence on the one source of information can be risky if that source has poor linkages or leaves the industry. The issue of working in isolation and the inability to seek second opinions in relation to farm management strategies is an issue facing many isolated farm operators.

Research has identified that those farmers who accessed quality information from primary sources tended to be more innovative in their approach to varietal adoption compared to those who did not. Noonan and Gorddard (1994) identified that farmer attitude towards new wheat varieties was largely determined by information source rather than personal experiences. It is evident that farmers' demand for information is increasing. Ortmann et al. (1993) believe that this is the result of market instability, more complex production technologies and a greater need for financial planning.

The relationships between the public and private providers of extension and advisory services to the farming community are continually evolving. Reduced government expenditure on services, and the need to foster change across rural industries is creating a challenge for all involved. According to Marsh and Pannell (2000), the dissemination of information has been hampered through competition between providers and contractors of agricultural research. The net flow of information between organisations has decreased, and collaboration curtailed. As State governments have reduced funding to traditional areas of extension, they have discovered that they have lost the capacity to

extend information of any significance to rural communities. As a result the private sector (through the involvement of commercial advisers) are now playing a more active role in the generation and dissemination of information (Patrick and Ullerich 1996, Cary and Wilkinson 1995), and are considered to have an increasing role in the future (Roseler et al. 1994).

There is the trend towards greater farmer reliance upon the services of commercial advisers as part of formal contractual agreements with input suppliers (Foltz et al. (1996). The input supplier likewise gains from the close association, in terms of having a captive market for input products, influence over the quality of product produced, and access to on-farm product for marketing purposes. The relationship between the private and public sector adviser can often be poor (Post 1988), with a need to develop closer working relationships between the two sectors (Bennett 1993). Marsh (1997) is of the opinion that if the private sector is to be involved in extension, there is a great need to develop closer associations with public organisations.

Despite the negative outlook in relation to the involvement of Government in the active delivery of extension programs into the future, Stephens (1997) believes that the public sector has a role in the future wholesaling of information. This according to Stephens will be complemented by the role of the private sector, which will include product development, promotion and monitoring of technologies. Opportunities for governments to wholesale information for distribution by agribusiness and other intermediary service providers are common practice in the USA (Claar 1988) and Holland (Roling and Jiggins 1994) where government has retained professional research and extension capacity. This leads to the issue of satisfying the learning needs of intermediary service providers, and to capitalise upon the knowledge of these providers through the development of a mutual learning environment (Wallace 1994). This requires the full support of all agencies and organisations involved in the research, development and extension process.

It is evident that the private sector will continue to become a major player in the dissemination of information to rural communities. It is important that they have the opportunity to assist in information development and distribution, and provide feedback from farmer participants, and be aware of the danger of focusing only on those aspects of extension/information transfer that are linked to commercial benefit for the company. Overall, there is benefit from fostering closer working relationships between government and the private sector in an effort to develop a suitable environment for information sharing and dissemination.

#### **2.4.6 Community (social) and agribusiness influences**

There are a range of pressures within the agricultural knowledge systems that influences the flow of information and its acceptance amongst stakeholders. These comprise community or social pressures and are directly related to the personalities of the stakeholders and social norms within the local knowledge system. Studies conducted by a number of researchers have identified that community or social pressures are considerable in relation to the acceptance or rejection of new technologies and farming practices (Sofranko 1984). Frank and Chamala (1992) consider that farmers make sound decisions through learnt experiences within their own social systems. Opinion leaders according to Rogers et al. (1988), serve as a model for the innovation behaviour of their followers, particularly when they are promoted as champions of the new technology.

#### **2.4.7 Marketing of information**

Extension based information is now being packaged and marketed to farmers either as stand alone or provided as a support tool to programs. Capuyan (1993) considered that in order to successfully market extension materials it was necessary to identify farmer needs. This process requires a soundly based marketing philosophy, comprising identification of the target audience, establishment of needs and then creating awareness for a particular product (Edelman et al. 1990, Leeuwis 1995, and Fujisaka 1994). Following on from this is the need to actively market and promote the services

and products (anon. 1993), with consideration given to client attitude and buying behaviour (Chappel 1994). Marketing of extension services has been described by Ray (1989) as social marketing, incorporating the use of media groups to create a multiplier effect. Funding pressures placed on the public extension has led to a greater emphasis being placed on needs analysis (Musser et al. 1994).

It is evident that information requires strong client focus in a format that can be readily interpreted and applied to a farming system, and endorsed by influential farmers. As a result a marketing approach to information dissemination may provide targeted outcomes than traditional information dissemination approaches. If a marketing approach is followed, there should be a far greater opportunity to identify and satisfy the needs of the targeted audience.

#### **2.4.8 The role of groups in knowledge sharing**

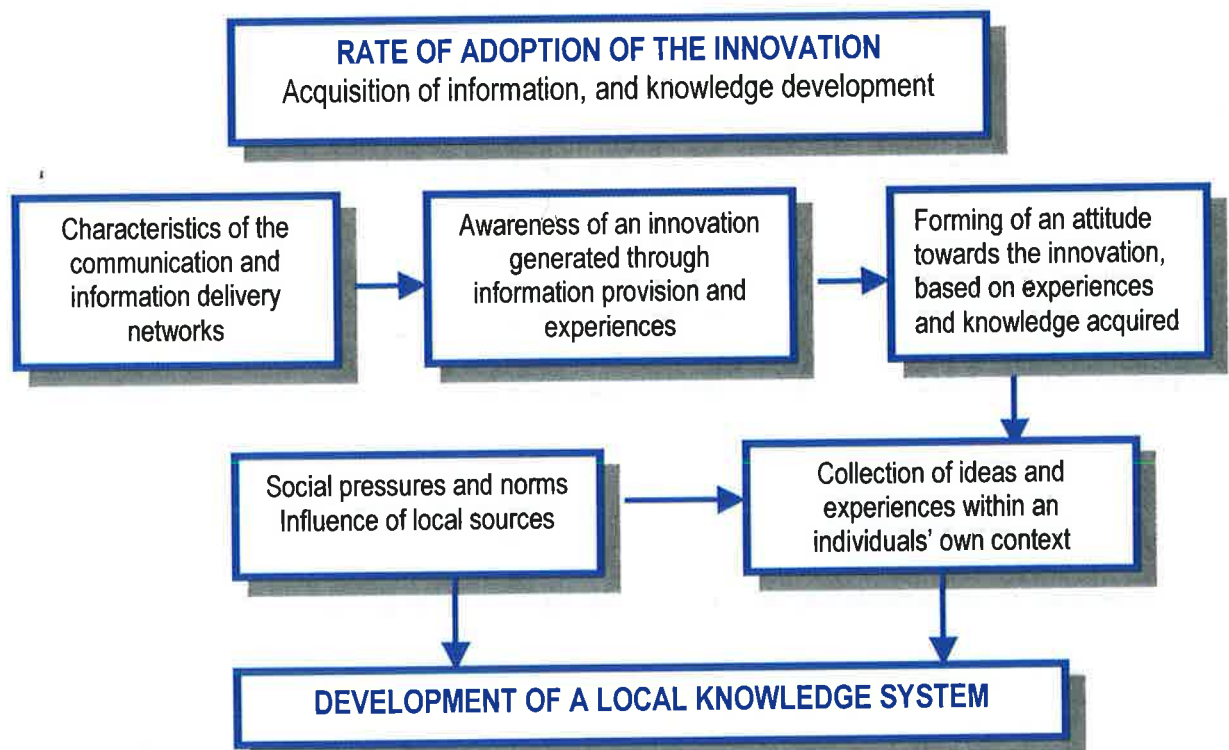
The popularisation of group based extension service delivery is evident across rural Australia, as governments and private organisations look toward more cost effective means of service delivery (such as group based delivery) to the farming community. There is the danger however of becoming too reliant upon these approaches (Marsh and Pannell 2000) as farmers have the potential to become grouped out, or in some situations prefer not to work or learn in any group based situation.

There are many benefits associated with a group extension approach, as long as the discussion is targeted within the context of a localised farming system. Groups offer the benefits of breaking down the barriers of farmers working in isolation. The ability to share ideas and experience, and discuss the application of new technology to a local farming environment are useful functions of a group. Group performance will be influenced by group health and the particular stage of development, and requires good leadership skills in order to motivate members (van der Kroon et al. 2002). Pretty and Chambers (1994) considered that groups were more effective during the earlier formative years, when participants were more motivated, and their greatest needs were being addressed. The notion

of self-sustaining groups has been important in developing functional group networks. Millar (1997) through observing farm groups identified the importance of the integration of local knowledge and experience into hands on practical training activities. This resulted in an enhanced ability to solve complex issues within the context of a local learning environment. Lockie et al. (1995) examined crop management practices of Australian farmers using focus group studies. They identified that whilst farmers had an awareness of farming practices, assistance was required in translating knowledge by advisers, through applying a farming systems approach.

Characteristics associated with information and knowledge systems influence the rate of adoption of an innovation (Figure 2.3). Ideas are generated through the provision of information, sharing of ideas and experiences. The dissemination of information into a knowledge system is an extremely complex exercise that is influenced by the social characteristics of the environment. By developing an understanding of the characteristics and influences associated with the knowledge system, strategies can be introduced in order to enhance the adoption process. This issue is addressed as part of the research approach adopted in this study.

**FIGURE 2.3: The influence of an agricultural knowledge system over adoption of innovations**



## **2.5 THE ENVIRONMENT OF ADOPTION**

The environment in which change takes place on-farm influences farmer decision-making and in turn adoption. The socio-economic characteristics of the environment can be described as personal (that of the farmer) and situational (the environment in which the farmer operates). The environment in which farmers are introduced to new information, communicate and share ideas is referred to as an agricultural knowledge system. The agricultural knowledge system is influenced by:

- Socio-economic characteristics of the farming environment and farmers themselves; comprising social, personal and situational characteristics,
- The environment of intervention, comprising technology characteristics, climate, community and industry - production characteristics.

These characteristics represent the major factors influencing technology adoption on-farm, and reflect the complex nature of farming. The social environment of farming influences the ability to access information, and develop favourable attitudes to new information. Vanclay (1992) believes social, structural and financial situations and processes have had the greatest influence over the adoption of conservation farming practices. The failure to adopt has not necessarily been influenced by a lack of available land management practices, with extension models in the past tending to ignore the social component of the farming system (Dent 1995). The environment in which the farmer operates is often a constraint to the adoption process. Factors as farmer isolation, low participation rates in extension activities, absence of local farmer leadership, poor attitude to technology, socio-economic status and education are considered to be major constraints to the adoption of new technologies and farming practices (Guerin and Guerin 1994).

### **2.5.1 Personal Characteristics**

There is a range of personal factors that influence the acceptance and adoption of new technology, and these are age, education, perceptions, attitudes, values, beliefs, self-concept and motivation.

An understanding of these factors can help draw together characteristics that influence adoption. In the following text, a summary of the range of personal characteristics are presented, all of which are considered to influence personal behaviour and in turn the adoption process.

### **Age and Education**

Personal characteristics influence technology adoption rates. Older and poorly educated farmers hindered uptake of knowledge and information (Somda et al. 2002, Rose 1996). Innovative farmers are considered to be younger; better educated; of a higher socio-economic status; and having higher levels of information access (Daberkow and McBride 2003, Bembridge and Williams 1990, Weatherford and Clegg 1997) and use of computers and the Internet (Hall et al. 2003). Work conducted by Zepeda (1990) found that extension programs that targeted the more educated farmers were likely to be successful in promoting management intensive technologies, and considered that programs need to target less educated farmers in order to maximise impact.

### **Attitudes**

Attitudes influence how individuals respond to an idea or situation in terms of behavioural change (Lynne et al. 1988). Attitude to risk influences the adoption of innovations (Lindner et al. 1982) and can be measured through observing a person's response to a range of attitudinal questions (Reich and Adcock 1979). If attitudes towards a certain technology are positive, there is less of a need for technical assistance and monetary incentives (Lynne et al. 1988, Allen and Bernhardt 1995). It is considered that attitudes are learnt and changeable but tend to remain stable over time as they tend to mirror experiences and socialisation (Vanclay 1992).

### **Values and Beliefs**

Values are considered to be the central ideal of an individual (Forest 1973) and assist in judging appropriate behaviour (Lynne et al. 1988 and Sofranko 1984). Individuals continually strive to achieve their values as part of a value orientation system, which is reflective upon the exhibited behaviour of an individual. Gasson (1977) proposed four classes of values; instrumental values (income generating capabilities); expressive values (pride of ownership, self-respect); intrinsic values

(enjoying work, independence) and social values (recognition, belonging to a community). Beliefs are related to attitudes and values that are shaped by prior experiences (Reeder et al. 1974). Beliefs refer to what people accept as truth (Sofranko 1984) and can act as mental barriers to adoption (Hallsworth 1987). Values and beliefs change over time and are influenced by contact people have with technology, cultural influences and conservatism (Sofranko 1984).

### **Motivation**

Motivation is considered to influence the level and rate of adoption (Guerin and Guerin 1994). Motivation is influenced by individual needs, personal and family goals. Motivation can be personal in nature (intrinsic) or driven through financial or physical rewards (extrinsic).

### **Perceptions**

Perceptions can't be directly observed however a person's thoughts can be examined through responses to specific questions (Rowan et al. 1994a). Perceptions influence how technology benefits are viewed with positive perceptions leading to higher adoption rates (Weatherford and Clegg 1997) and negative perceptions acting as barriers to technology adoption (Ennew et al. 1992). Through the early identification of perceptions that influence decision-making processes there is the opportunity to focus investments in research and extension more effectively (Llewellyn et al. 2005).

### **Self-concept**

Self-concept relates to an individual's personal view of himself or herself. Self-concept is considered to be a collection of attitudes that an individual holds about him or herself and continually evolves (Seabrook and Higgins 1988). Self-concept influences decision making processes and in turn uptake of technology by individuals.

## **2.5.2 Situational characteristics**

Situational characteristics associated with the farm business influence adoption of technology. There are ranges of characteristics that have a direct impact. External influences, such as market force pressures and globalisation significantly impact on farm businesses. As an example, declining terms

of trade faced by Australian grain growers continue to impinge on the ability of farm businesses to remain financially viable (Webb and Curtis 2003) and readily adopt new technologies.

Physical farm features likewise influence the ability for a farm business to adopt a range of technologies and farming practices, primarily due to the scale of operations, and the ability to generate additional farm income (Foltz et al. 1996, de Janvry and LeVeen 1983), in the financial viability of the farm business. It is generally only those farms that have the financial security that are likely to adopt improved farming practices and systems (Thampapillai and Anderson 1994, Feder and Slade 1984, Fliegel 1984), whilst those that are in survival mode are sometimes inclined to make irrational decisions relating to farming practice adoption (Foster and Rausser 1991).

Linked to the financial capacity of the farm business are elements associated with risk management – price variability, market uncertainties will likewise influence adoptive behaviour (Patrick and Ullerich 1996). Producers often respond to risk by balancing the overall threat of risk across the farm business. More often than not farmers play a balancing act between the needs of the business and satisfying their personal and economic interests (Vanclay 1992).

The farm family structure and relationships will also influence the rate at which new technology is taken up by the farm business. The ability of the family to operate together, discuss and evaluate new practices is essential if new technology is to be adopted and the farm business advance.

### **2.5.3 Technology Characteristics**

In order for technology to be adopted the benefits (compatibility, simplicity and observability) need to be clearly demonstrated (Barao 1992). The gradual accumulation of favourable experiences associated with the technology (Saha et al. 1994, Feder and Slade 1984), assuming it is profitable (Saltiel et al. 1994), is likely to be more readily adopted within a farming systems context (anon.

1994, Lindner 1986). The technology must also have a relative advantage over traditional practices (Rogers 1995, Cary et al. 2001).

### **Managing technological risk**

The environment in which Australian farmers operate influences their attitude to risk and adoption behaviour. According to Ghadim et al. (2005) adoption decisions are influenced by the farmer's perception of riskiness and attitude to risk. External factors influencing risk are climatic variability and commodity prices (Anderson et al. 1994) combined with physical farm characteristics (Stanford et al. 1994). Bond and Wonder (1980) are of the opinion that Australian farmers are more likely to accept lower average incomes in order to reduce variability in income.

Ashton (1996) identified that farmers in low rainfall districts were less inclined to target higher yields due to associated risks of various technologies, leading to lower adoption rates (Purvis et al. 1995). Weisensel et al. (1991) found that soil moisture levels within paddocks were the principal factor farmers considered most when developing appropriate risk management strategies relating to crop sowing practices. To what degree risk plays in adoption decisions is difficult to assess due to complexities within the environment of intervention.

#### **2.5.4 Decision-making characteristics and processes amongst farmers**

Decision-making processes are often based on an analysis of information and facts within the context of an individual's environment. The ability to gain an insight into decision-making processes is challenging as there are a wide range of intervening factors.

It is the context in which decisions are made that will be influenced by the personal and situational characteristics of the farmer (Howard et al. 1997). This leads to adoption behaviour of the individual (Feder and Slade 1984). McLeay et al. (1996), van Tassell and Keller (1991) identified the need to

develop a greater understanding of the exact role various factors play in the decision-making process of farmers. Pannell (1995) believes that it is the information suppliers who have failed to fully appreciate the complex decision-making processes undertaken by farmers. How do farmers make use of available information in formulating decisions? By gaining an understanding of these processes it is then possible to better target the type of information that is provided to farmers.

It is often difficult to describe how farmers make decisions (Howard and MacMillan 1991). Decision-making processes are based on the level of information provided, and is considered part of a learning process (Saha et al. 1994). The process in which the information is transferred into decision-making is difficult to describe (Rowan et al. 1994b). Any decisions that are made require a critical level of information (Feder and Slade 1984) carried out within the context of knowledge based systems environment (Roling and Jiggins 1995) that are influenced by social pressures within the system (Willcock et al. 1999). Fountas et al. (2006) described the Dutch researcher Peter Checkland's approach to developing a better understanding of farmer decision making through the criteria of addressing a number of key questions; What information is required to carry out the activity, the source of this information and its form and frequency?; What information is generated from the activity and the generated information's characteristics?; Who is the recipient of the information?

The environment in which decisions are made will also influence the decision-making processes. van Tassell and Keller (1991) found that the decision-making processes of farmers are strongly influenced by the economic, political and environmental environment. Lynne et al. (1988) believed that past experiences likewise influences the decision-making processes whilst Prevost (1996) considered attitude to risk and personal views influenced decision-making processes. Sjab et al. (2001) identified many diverse reasons as to why farmers chose to produce certain crops and not others, influenced by environmental conditions and risk.

Extension processes often assist in providing information that assists in decision-making processes (Dexter 1988). Whilst this may describe an ideal system for farmer support and guidance, Vanclay and Lawrence (1995) are of the opinion that farmer decision-making is not based on formal rationality. The decision to adopt a specific technology often goes through a process of adaptation. Anderson (1993) describes the process as making something suitable for a designated purpose, or fitting something in where it has previously not existed. According to Hildebrand (1988) adaptation is dependent upon the skills of the farmer.

Decision-making can be described as a process of identifying a perceived need or desirable outcome. Information is then gathered, and reflected upon (based on the individuals' experience and knowledge). The potential benefits of various outcomes are then weighed up and internal trade-offs take place. A change in behaviour will result from the individual perceiving a particular set of rewards or outcomes. A decision to act or not, and a possible choice of alternatives is then made.

Zepeda (1990) considered that adoption decisions occur simultaneously, with many decisions relating to the adoption of one specific practice linked to other similar decision-making processes. Studies confirmed that farmers with lower levels of education were less likely to adopt the management intensive technologies as were older farmers who had problems dealing with the complexities of such technologies. This work is supported by recent research, as described by Fountas et al. (2006) who categorised farmer decisions on the basis of strategic, tactical and operational. Each category of decisions varied in its complexity, and required differing patterns of information acquisition. From the research studies undertaken it is evident that specific farming practices are adopted in blocks of associated practices, characteristic of adoption taking place from a systems perspective as opposed to random adoption.

### **2.5.5 Characteristics of the decision-making environment**

The decision-making environment associated with technology adoption is influenced by a wide range of personal and situational characteristics with many stakeholders failing to fully appreciate the complexities involved. Prevost (1996) believes that decision-making is a dynamic process undertaken in a complex farming environment. Supporting this is Pannell (1995) who found that agronomic decisions made by farmers were influenced by short-term profit factors, agronomic interactions and management, sustainability issues, risk and whole farm factors. Decision-making by farmers has been improved through goal setting as identified by Harling and Quail (1990). This strategic approach to management is supported by Long and Villareal (1994) who consider it critical to successfully managing a farm business.

Research has also identified that adoption of new technologies will be strongly linked to the earning potential arising from adoption, as is the case in precision farming technology (Roberts et al. 2002) and the management of herbicide resistance (Pannell 2002). It is also evident that farmers differ in their own risk management strategies and attitude to risk (Patrick and Musser 2002).

#### **Decision Support Systems**

Decision support models aim to assist farmers in decision-making processes, and are often used in the absence of technical expertise. Such models are sometimes referred to as expert systems and are the accumulation of field observations and scientific theory (Swinton and King 1994). Often they are applied to management input decisions associated with weed and pest control, fertiliser input and marketing decisions. Decision support systems provide a means of guiding the users in a logical sequence as the most appropriate action to take with a prediction of the outcomes arising from recommendations. Through gaining a better understanding of the decision-making processes that farmers undertake it is possible to identify why farmers make specific adoption decisions. This

will help to explain behaviour in a logical framework, and in turn describe their behavioural characteristics or farmer typologies.

## **2.6 DEVELOPING AN UNDERSTANDING OF FARMER TYPOLOGIES**

Significant research has been conducted that has attempted to explain the behavioural characteristics of farmers. The study of farming styles is considered by Howden et al. (1998) to offer the opportunity to provide an alternative model for explaining adoption behaviour through identifying a wide range of management strategies utilised by farmers (and the rationale behind these).

Farming styles are based on the presumption that farming is a social process comprising elements of social, political, cultural and farm management elements, and it is on this basis that specific styles are described. Similarly farming typologies can be defined as descriptive names that assist in the classification of farmers (based upon the measured patterns of variation that exist within a given population (Emtage and Suh 2006)). The nomenclature of farming typologies is reflective of the most dominating characteristics associated with the groupings. Farming typologies and styles in essence are inter-changeable terms describing the same thing, with the exception that farming typologies may in many instances be derived from a higher degree of statistical rigour (with reference to the analysis of the socio-economic characteristics of the target population in question).

There are ranges of different approaches that have been undertaken by researchers to describe farmer typologies or styles. The development of a farming styles approach in Australia was initiated by Vanclay and Howden, based upon the work of Dutch sociologist van der Ploeg (Maybery et al. 2005). Howden et al. (1998) identified specific farming styles largely on the basis of qualitative analysis and the perceptions of extension officers and farmers. A range of farming styles developed by Howden were modified after receiving feedback from extension officers involved in the study. These styles were then open to interpretation by farmer focus groups, which were asked to identify

which specific styles they themselves thought described their own personal characteristics. Following on from this work, Thomson (2001) was able to identify specific groupings of farmers derived from farmer responses to a range of attitudinal and goal statements.

Maybery et al. (2005) was able to classify farmers on the basis of economic, conservation and lifestyle characteristics. This process was considered by Maybery et al. (2005) to be beneficial in terms of creating a greater understanding of farmer decision-making processes, and in turn altered behaviour through practice change. Such an approach was driven from the need to introduce or influence change, as an active management tool by an external influence point. This study and others, such as that of Brodt et al. (2006) described a range of pre-conceived typologies prior to the study of the target population. This approach may lead to research bias, through trying to make the data fit the researcher's perceptions of what typologies may exist in the target population. Quite often a farmer may be viewed as being backward in one area of enterprise management, and then viewed as being innovative in another area.

This research thesis seeks to identify farmer typologies through observing the characteristics of the target population, free from any pre-conceived ideas of what typologies are likely to exist. Based upon this, the study then aims to examine how best change can be implemented across the target population, guided by farmer typologies and the needs and aspirations of the target population. These aspects will be discussed in further detail in Chapter 3 (Research Design and Methodology).

## **2.7 KEY AREAS OF FOCUS FOR THIS STUDY**

Significant changes have occurred in relation to the delivery of extension services in Australia during the post-war period since 1945. Traditional government extension delivery models are under increasing pressure resulting from a shift in government policy in relation to the level of resourcing applied to extension services. The government agenda has shifted from one of providing technically

based delivery systems to one of policy and regulations characteristic of service provision today. Mixed messages from government have created confusion amongst farmers as to the degree to which governments are willing to support agriculture. Farmers themselves recognise the need to increase their own personal capabilities through creating self-directed learning opportunities.

The commercialisation of research and extension services has had a significant impact on the availability of free information in the community as many government agencies have adopted a cost-recovery or user-pays system. The efficiency in which information is transferred within rural communities is questionable, as is the ability of farmers to adequately access services that can assist in developing their capabilities to adopt new technologies. In this environment of change, extension itself is being challenged in order to define its own identity and role in the change process.

Often research and extension professionals have failed to appreciate the personal situation of the farmer. Often non-adoption has been the result of a logical and thought out process performed by farmers. Technologies are adopted in logical sequences in a step-by-step manner, in a sequential manner. This is a characteristic of the technologies and farming practices themselves, in that many are inter-related from a farming systems perspective. The implications of how farmers manage risk in low rainfall environments is poorly understood by professionals, and yet is considered by farmers to influence adoption behaviour. The agricultural knowledge system is extremely complex with many interactive variables associated with communication systems. Contributing to these are community and social pressures associated with the adoption process, which can often be difficult to predict. It is necessary to explore these relationships in further detail, so that a better understanding of adoptive behaviour by farmers are developed - if extension systems are to be in any way successful in the future.

In many instances, information is made available to farmers in the hope that adoption will be the result, with little appreciation by research and extension professionals of the need to ensure that information is relevant, practical and adaptable to local farming systems environments. This study aims to develop a better understanding of the characteristics and influences associated with knowledge systems, and develop approaches that lead to improved systems of change.

A wide range of personal and situational characteristics, reflective of the environment in which they operate, influences adoption processes by farmers. Farmer typology classification systems have been open to interpretation by both the research and farmer audience. There has been little work conducted that adequately interprets such research work, in terms of applying farmer typology descriptives to a targeted extension approach that utilises market segmentation techniques. This opportunity represents a key approach that will be introduced into this research study.

## **2.8 RESEARCH QUESTIONS AND HYPOTHESIS**

The literature review has provided the framework in which research methodologies can be developed, in order to address the research questions (as presented in Chapter 1):

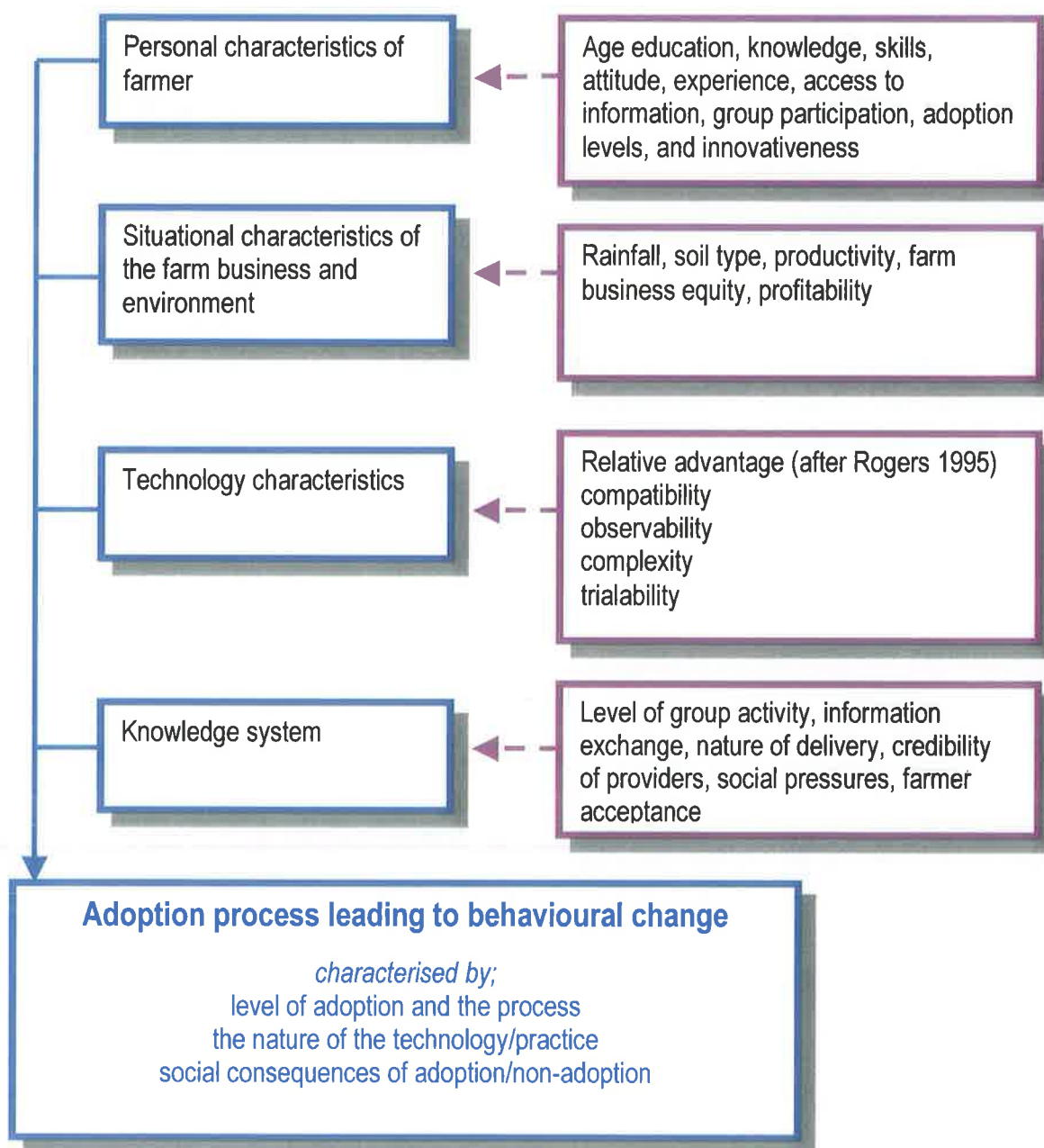
1. Do farmers differ in their personal and situational characteristics, on the basis of their level of adoption, innovativeness and production capability?
2. Is it possible to utilise market segmentation approaches in order to describe farmers according to their personal and situational characteristics and adoptive behaviour?
3. To what degree is the adoption of technologies by farmers influenced by
  - (a) Characteristics of the agricultural knowledge system?
  - (b) Characteristics of the technology itself?

These questions have been developed in order to develop an enhanced understanding of the extension process, and identify the complexity and interaction between a wide range of factors and influences, and lead to the hypothesis for this study;

**The adoptive behaviour of farmers is influenced by the nature and complexity of the agricultural knowledge system, and personal and situational characteristics.**

Figure 2.4 presents a conceptual model of the factors and characteristics that influence the adoption process, which represent key elements associated with this study. Chapter three will provide a detailed background in relation to the research methodologies adopted in this study.

**FIGURE 2.4: An overview of the conceptual model developed for this research study**



## Chapter Three

### RESEARCH DESIGN AND METHODOLOGY

This chapter provides a detailed overview of the research methodology used in this study including survey design, data collection procedures, data entry and analysis. The research design and methodology adopted in this study involved both quantitative and qualitative approaches. Quantitative research tools focussed upon the collection and analysis of data from a survey questionnaire, distributed to South Australian farm businesses that were engaged in grain production. Whilst the survey questionnaire primarily collected quantitative information, it also collected qualitative information relating to adoption characteristics associated with farming practices and new technologies.

The collection of quantitative information provided the opportunity to develop a statistical basis for identifying elements of association between personal and situational characteristics (measured variables), knowledge systems characteristics and adoptive behaviour. The quantitative research approach was used to identify specific trends and associations that warranted further investigation, either through further statistical analysis, or qualitative research approaches. The market segmentation approach was used to establish the extent and nature of variability across the survey population, as well as to identify specific clusters of farmers.

The utilisation of qualitative research tools has enhanced the understanding and interpretation of survey findings, effectively 'bringing about meaning' to quantitative results. As indicated earlier, some qualitative information was collected through the survey questionnaire: however a much larger body of information was collected through conducting a series of focus group workshops. The workshops targeted farmers involved in grain production, with sessions comprising presentation and feedback of survey results. Workshop discussions focused upon specific case studies linked to the adoption of specific technologies, on-farm risk management strategies and characteristics of agricultural knowledge

systems. The ability to gain informal feedback from the workshops provided the opportunity to develop a far greater understanding of farmer behaviour and adoption.

In effect, both quantitative and qualitative research approaches have complemented one another, with quantitative tools providing the 'hard statistical basis' for describing the characteristics of the research audience and their environment, and qualitative tools helping to provide a practical and meaningful interpretation of the quantitative data, and farmer responses to the different case studies conducted as part of the focus group workshops. The relationships between the quantitative and qualitative research approaches are summarised in Figure 3.1.

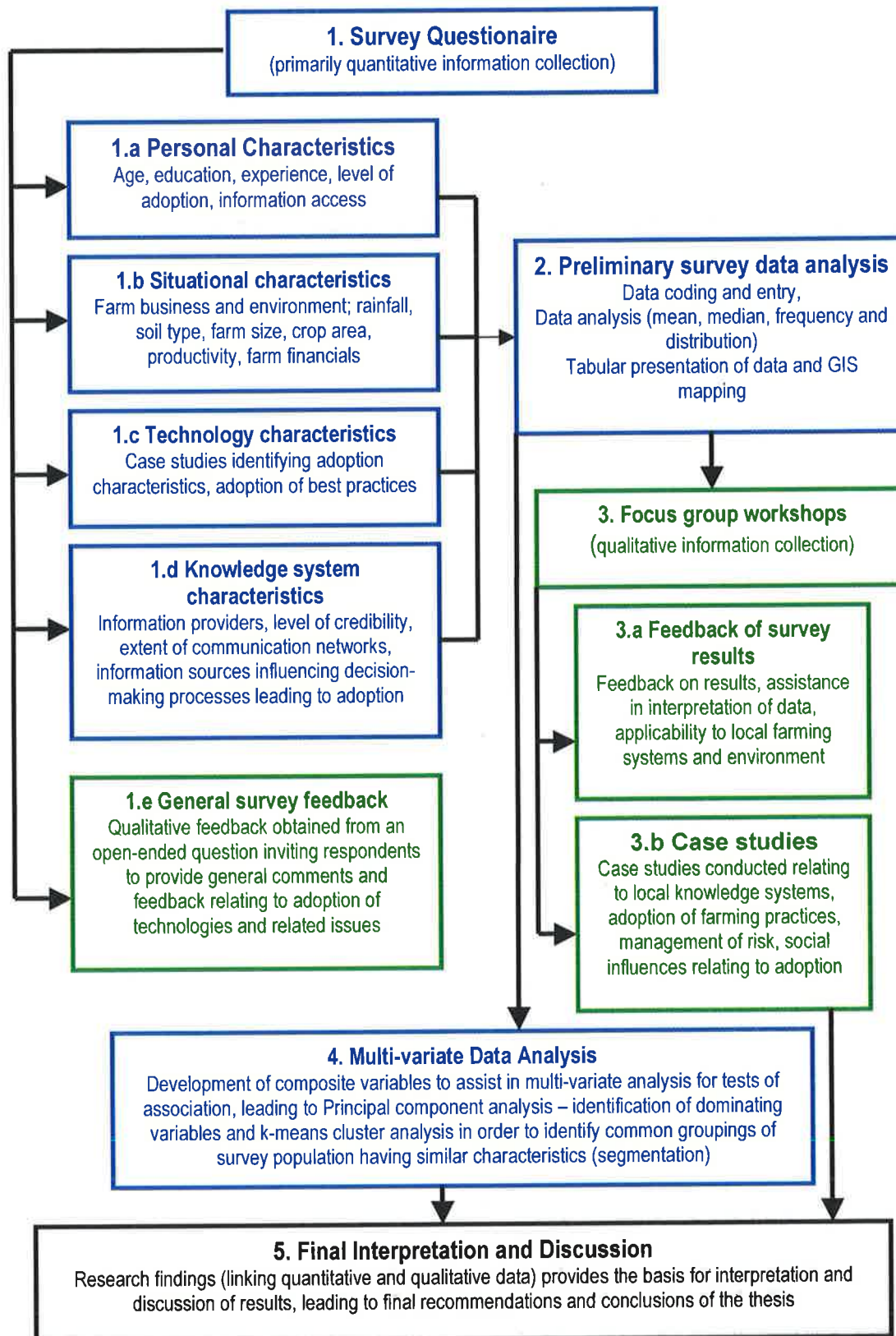
### **3.1 SURVEY QUESTIONNAIRE**

In order to address the research questions posed in this study, it was considered that a survey questionnaire would be an appropriate research tool capable of collecting data that would address the research questions and hypotheses associated with the target population. Self-administered questionnaires are considered to be one of the most cost-effective means of collecting survey information (Fink and Kosecoff 1985).

#### **3.1.1 Survey population overview**

The audience chosen for this study comprised the managers of farm businesses involved in cropping enterprises across the agricultural districts of South Australia. Utilising the grower database of the South Australian Co-operative Bulk Handling (SACBH) Company, farm businesses that on average delivered a minimum amount of 100 tonnes of grain (over a three-year period 1994-96) received a copy of the

**FIGURE 3.1: Relationships between the data collection tools and approaches highlighting relationships between quantitative (blue text) and qualitative (green text) data sources, and the sequence of data collection and analysis.**



survey questionnaire. Surveys were sent to 4,470 farming businesses, with responses received from 2,472 of these, representing an overall response rate of 55.3%.

### **3.1.2 Characteristics of the survey study area**

The survey targeted farmers engaged in rain-fed grain production from across South Australia located in the regions of Eyre Peninsula, North, Yorke Peninsula, Mallee and South East. Figure 3.2 provides an illustration of the regional locations, in addition to identification of the Counties located within each of these.

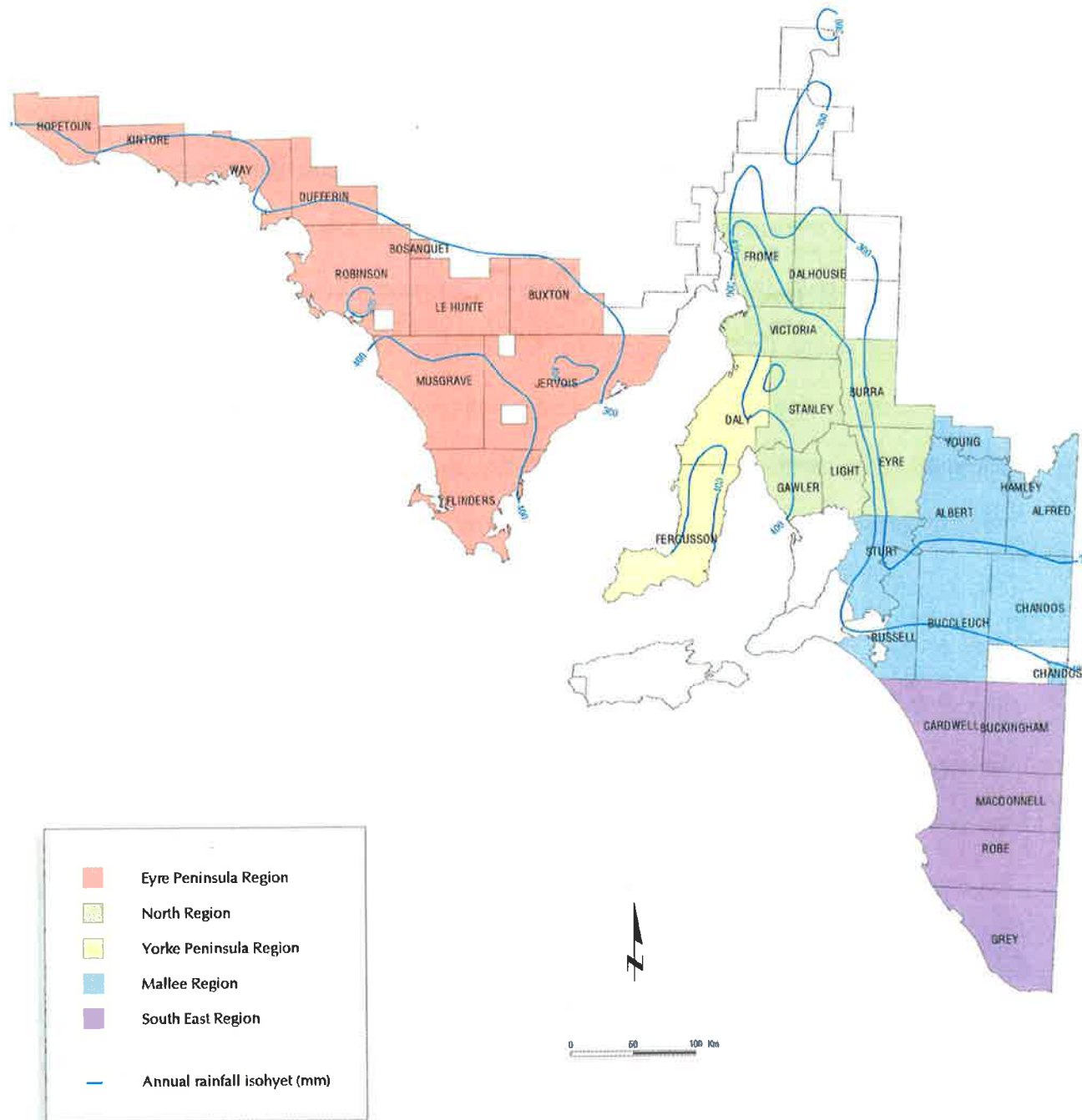
Farms are in most situations family owned and run (in partnership arrangements involving both genders). The survey did not set out to identify any specific gender influences in relation to the adoption of technologies. Whilst the survey targeted the 'main decision-maker/manager' of the farm business, it is evident from informal comments provided by many respondents that the survey was completed jointly by both male and female partners associated with the farm family business. Therefore, the responses recorded have been interpreted as shared views, representative of the opinions and experiences of both genders involved in managing the farm.

The farming businesses are also characterised by the employment of some casual labour (on a seasonal basis) during periods of peak workload, such as during seeding and harvesting operations. Whilst some properties are generally cropping only, others also rely on livestock enterprises (dominated by sheep).

Agricultural production is predominantly a dryland rain-fed cropping system and experiences a semi-arid Mediterranean climate. Annual rainfall ranges from 250mm through to 450 mm, with the low rainfall

districts including the Upper North, Upper and Western Eyre Peninsula and Mallee regions, whilst the medium to high rainfall districts are confined to the Mid North and Lower South East.

**FIGURE 3.2: Regions (comprising Counties and featuring annual rainfall isohyets) used in the Cropping 2000 survey and associated research study**

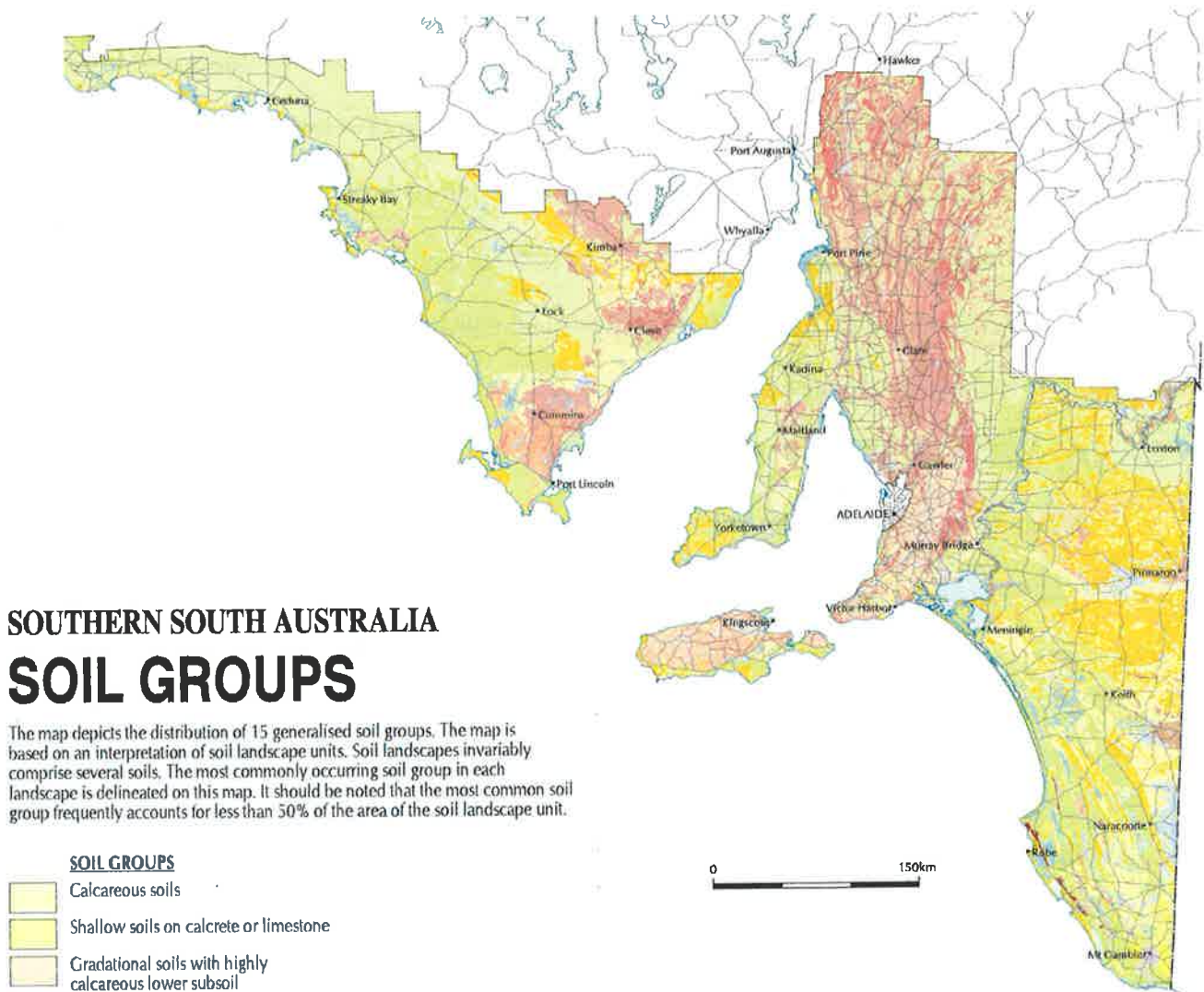


The farming systems involve crop rotations including cereals (wheat, barley, triticale, oats and rye), pulses (peas, faba beans, lentils, chickpeas, vetch) and canola, grown over approximately 3.4 million hectares (Carmalt 1998). Pastures for livestock are generally self-regenerating, however sown and improved pastures can include lucerne, sub-clovers, medics, cereals as well as in some instances summer growing fodder crops. The combined value of production for wheat and barley at the time of the survey was \$960 million (Carmalt 1998).

The growing season occurs from April to October, with opening season rains occurring from late April onwards. Rainfall is greatest during the months of May, June and July. Crops are generally sown from mid to late May onwards, with crops in lower rainfall environments tending to be sown as early as practical in the season. Crop sowing practices may be delayed in frost prone districts in order to reduce frost risk during the flowering period of cereal crops in the spring period. Plant growth rates are greatest during the spring months, boosted by warmer daytime temperatures and available soil moisture. Mild winter temperatures occur along the coastal districts during winter months (Webber et al. 1976).

Soils on Eyre Peninsula vary from infertile calcareous sandy soils (common to the coastal fringes) through to clay loam soils on lower Eyre Peninsula and northern cropping fringes. Mallee soils are variable, ranging from shallow loamy soils over limestone rubble base across the region through to deep sands in the Southern Mallee. Soils in the South-East range from self-mulching black clay soils in the lower South East through to non-wetting deep sands in the Upper South East. Soils in the North region are characterised by red-brown earths over much of the region, through to light Mallee soils on the coastal fringes. Yorke Peninsula soils are generally sandy loam over clay (Mallee type soils), through to deep calcareous sands on lower Yorke Peninsula. Figure 3.3 summarises the types and distribution of the major soil types across the agricultural districts of South Australia, and can be used to help interpret agricultural production capabilities and constraints to the adoption of different farming technologies.

**FIGURE 3.3 Major soil groups of South Australian agricultural districts**



## SOUTHERN SOUTH AUSTRALIA SOIL GROUPS

The map depicts the distribution of 15 generalised soil groups. The map is based on an interpretation of soil landscape units. Soil landscapes invariably comprise several soils. The most commonly occurring soil group in each landscape is delineated on this map. It should be noted that the most common soil group frequently accounts for less than 50% of the area of the soil landscape unit.

### SOIL GROUPS

- Calcareous soils
- Shallow soils on calcrete or limestone
- Gradational soils with highly calcareous lower subsoil
- Hard red-brown texture contrast soils with alkaline subsoil
- Cracking clay soils
- Deep loamy texture contrast soils with brown or dark subsoil
- Sand over clay soils
- Deep sands
- Highly leached sands
- Ironstone soils
- Shallow to moderately deep acidic soils on rock
- Shallow soils on rock
- Deep uniform to gradational soils
- Wet soils
- Volcanic ash soils
- Rocks

In terms of soil fertility and physical characteristics, South Australian soils are deficient in phosphorus and nitrogen, and as a result require such fertilisers at seeding. Topdressing of nitrogen fertiliser post-seeding, particularly in the higher rainfall environments are generally undertaken during favourable seasons when good winter rainfall is received. The highly calcareous soils of Eyre Peninsula are noted for restricting the availability of applied phosphorus fertiliser, and respond to applied phosphorus in liquid formulation. All soils are generally low in organic carbon (1.0% or less) and vary from being slightly acid to highly alkaline (Webber et al. 1976). Most soils have favourable soil structure; however because of their shallow depth wind erosion can be a problem (if cultivation occurs with minimal soil cover), particularly in the Mallee and Eyre Peninsula regions. In the North, water erosion can be a problem on the red-brown earths, particularly on areas cultivated over summer where thunderstorm activity can result in short and intense rainfall events. Dryland salinity is an issue on areas associated with rising water tables, notably lower Eyre Peninsula, southern Yorke Peninsula, and the Upper South East districts

### **3.1.3 Questionnaire design and pre-testing**

Questionnaire design and content were derived from the research aims, literature review and hypothesis. Relatively simple questions were placed at the start of the survey in order to provide a comfortable start to the questionnaire, a strategy recommended by Vernon (1983). Questions were kept interesting and meaningful, an approach recommended by McGhee (1983).

Pre-testing of survey questionnaires can help to improve the reliability of questionnaire design and assist in reducing any bias (Shepard 2001). Draft surveys were pre-tested amongst selected thirty farm businesses selected from across the targeted survey area. Feedback on survey content, questionnaire design, readability and the quality of data likely to arise from the survey was obtained. Appropriate

changes were made to the survey content, question design and presentation prior to the final production and distribution of the survey. A copy of the survey questionnaire is contained in Appendix A.

A promotional strategy was developed in order to maximise the awareness and response by respondents. The survey was titled *The CROPPING 2000 survey* and was endorsed by major industry organisations including the State Minister for Primary Industries. An introductory card (advising the audience of the arrival date for the questionnaire) was distributed on the 18<sup>th</sup> July 1997 (refer to Appendix B). The survey was sent out ten days later on the 28<sup>th</sup> of July 1997 and a follow-up reminder card twelve days later on the 9<sup>th</sup> of August 1997 (refer to Appendix B). This approach was used in order to maximise survey response as recommended by Babbie (1990). All correspondence associated with the survey was distributed via Australia Post.

#### **3.1.4 Survey response rates**

Surveys were received from respondents over a ten-week period (with rates of questionnaires received provided as a summary in Table 3.1). Some 75% of responses were received by the return due date. Of the 4,563 surveys distributed, 93 surveys were excluded from the final sample as a result of participants receiving duplicate copies (8), or respondents having either retired from full-time farming or had left the industry (85), resulting in a maximum of 4,470 eligible responses. There were 2,472 completed surveys returned, representing a response rate of 55.3%.

**TABLE 3.1: Rate of return of survey questionnaires from respondents**

Weeks after survey distribution	Number returned	Cumulative response rate (%)
1	716	16.0
2	597	29.4
3 (return due date)	604	42.9
4	310	49.8
5	140	53.0
6	64	54.4
7	24	54.9
8	9	55.1
9	6	55.3
10	2	55.3
Total	2472	55.3%

Table 3.2 summarises response rates for each region. Response rates ranged from 18.3% in the Hills and Kangaroo Island to 70.7% in the Mallee. Data from the Hills and Kangaroo Island was excluded from analysis due to the relatively small number of respondents (13 respondents, providing an 18.3% response rate).

**TABLE 3.2 Number of survey respondents and response rates from each region**

Region	Number of replies	% Response rate per region	% Total responses
South East	169	55.1	7.2
Mallee	359	70.7	15.3
North	759	48.4	32.4
Yorke Peninsula	375	53.7	16.0
Eyre Peninsula	665	52.3	28.4
Hills & Kangaroo Island	13	18.3	0.6
Total	2340		100%

### **3.1.5 Variables and their measurement**

The questionnaire contained a range of variables considered to assist in explaining the nature of the adoption process. Analysis of the survey data provided the opportunity to examine in detail the socio-economic (personal and situational) characteristics, adoption behaviour and nature of the knowledge system. Variables utilised in the study included the following;

- Personal characteristics (age, education, experience, decision making characteristics and attitudes)
- Situational characteristics (farm size, location, rainfall, crop factors (type, area and yields), and financial factors)
- Agricultural knowledge systems characteristics (source, frequency and usefulness of information, characteristics associated with local knowledge systems)
- Innovation characteristics (patterns of adoption behaviour, perceived barriers, benefits of technologies, level of adoption)
- Qualitative information (sourced from survey and workshop feedback)

## **3.2 DATA ANALYSIS**

Research questions posed in this thesis were addressed through the analysis of survey data, with the primary aim of contributing to the acceptance or rejection of the hypothesis. In order to ensure that data collected was of relevance to the research study, the question, "*how will this data set contribute to the structure and argument of the thesis?*" was often asked. It was necessary to judge whether or not the data generated could be used for further analysis of specific research questions or contribute to the identification of relationships between variables used in the analysis.

Data relating to crop yields and areas sown were collected for a wide range of crop types in response to crop forecasting requirements for Primary Industries and Resources SA (PIRSA) (who assisted in

supporting survey distribution and analysis costs). As a result, some of the additional crop type and yield data was excluded from presentation in this thesis, as it was not directly related to the research questions and hypothesis posed in this study. Data for wheat was however presented in the thesis, as this adequately illustrated crop production and water use efficiency characteristics associated with the target population.

In order to manage the large number of personal and situational variables recorded from the survey questionnaire, it was necessary to collapse variables through the introduction of new variables capable of summarising groupings of data. These variables (as presented in Table 3.3) were then used for further data analysis to test the hypothesis. A full description of the variables (including those derived from a sub-set of original variables) including mean, median and standard deviation values are presented in Appendix D.

In some instances there were missing values associated with some of the variables sought from the survey respondents. Missing values were dealt with on a variable-by-variable basis. In general (unless otherwise specified in the presentation of results), those survey responses where variables were missing were omitted from the analysis of survey data (in relation to that specific variable).

**TABLE 3.3: Summary of variables (including derived variables)**

Variable type	Variable name	Description
<b>Personal characteristics</b>		
	Age range	Age of respondents (by category)
	Education	Level of formal education achieved
	Farming experience	Years involved in managing the farm business
	Innovativeness	Score based on response to number of attitudinal statements relating to adoption of practices
	Outlook on farming	Score based upon responses to number of attitudinal responses relating to new technology, long term financial viability outlook, and a personal ability to increase crop yields on-farm
	Viability	Score based on concern towards long term viability of own farm business
<b>Situational characteristics</b>		
	Growing season rainfall	April to October mean growing season rainfall
	Equity	Percentage equity in the farm business, calculated by subtracting farm borrowing from total farm asset values
	Wheat crop yields	Current yield (tonnes per hectare)
	Yield potential (%)	Percentage yield potential achieved (based on growing season rainfall, using the French-Schultz yield potential model)
	Future yield increase	Future increase in wheat yield, based on expected yield (5 years time), minus current yield, divided by 5), expressed as kilograms per hectare per annum
	Total grain	Cumulative total of all grain produced (yield average multiplied by average area sown for each crop type)
	Ratio of broad leaf crop	Cumulative total of pulse, canola and pastures sown divided into total crop area sown (including cereals)
	Cropping intensity	% of total farm area sown to crop in any one year
<b>Access to information</b>		
	Total information sources	Total number of different information sources accessed
	Total electronic sources	Total number of different electronic sources accessed
	Total personal sources	Total number of different personal sources accessed
	Total print sources	Total number of different print sources accessed
	Total group involvement	Total number of different groups participated in
	Total field day involvement	Total number of different field days participated in

**TABLE 3.3: Summary of variables (including derived variables) continued**

Variable type	Variable name	Description
<b>Adoption characteristics</b>		
	Best practice	Adoption score relating to 16 specific practices, equal weighting for each, with adoption scores applied according to level of adoption, 1.0 = complete, 0.75=partial, 0.5= dis-adoption, 0.25 = if intend trying
	Time lag	Average time lag from when respondent became first aware of the innovation until when adoption took place (cumulative score for three different practices; wheat protein management, grain marketing and herbicide resistance risk management)
	Crop establishment adoption	Adoption scores relating to farming practices (crop sowing / seeding system management)
	Crop nutrition adoption	Adoption scores relating to farming practices (crop nutrition monitoring and management)
	Weed management adoption	Adoption scores relating to farming practices (weed and pest monitoring and management)
	Grain marketing adoption	Adoption scores relating to farming practices (grain marketing risk management and grain handling)
	Crop rotation adoption	Adoption scores relating to farming practices (crop rotation planning, varietal use and risk management)

### 3.2.1 Summary of data analysis procedures

Due to the relatively complex nature and the large set of information collected from the survey, it was necessary to develop a system of data interrogation and analysis. The procedures utilised in collecting and analysing the data from the survey are summarised below.

#### Questionnaire development.

Initial framing of questions were undertaken with consideration given to analysis and data coding requirements. Pre-testing of the survey and review prior to final distribution completed the development phase.

### **Data coding and entry of survey data for analysis.**

All qualitative data were initially assigned a number reflecting the postcode of the respondent, in order to later track comments on a regional basis. Many of the responses (codes) were later grouped into a smaller set of broad categories in order to facilitate further analysis.

### **Initial data description (mean, media, distribution).**

The basic description tools (mean, median and distribution) were used to help understand the overall nature of the data collected, and determine which variables could be incorporated into the analysis.

### **Data summary**

Data were later summarised on a district, regional and state basis. Selected data were later transferred to a GIS based state mapping system for presentation of results on a geographical basis. This information was then presented as part of a series of focus group workshops.

### **Establishment of linear relationships**

Pearson's correlation analysis was undertaken, helping to establish linear relationships between variables.

### **Tests of association**

Chi-square tests of association were used for the comparison of variables, including quartile analysis.

### **Identification of complex relationships**

Principal component analysis and cluster analysis techniques were utilised in order to identify complex relationships between data sets, and helped to identify segmentation of respondents (based on similar sets of characteristics), forming the basis of assigning farmer typologies to clusters.

### **3.2.2 Summary of data analysis techniques**

A summary of data analysis techniques, in terms of statistical function and specific statistical procedures used are presented in Table 3.4, with an illustration of the stages of data preparation and analysis provided in Figure 3.4.

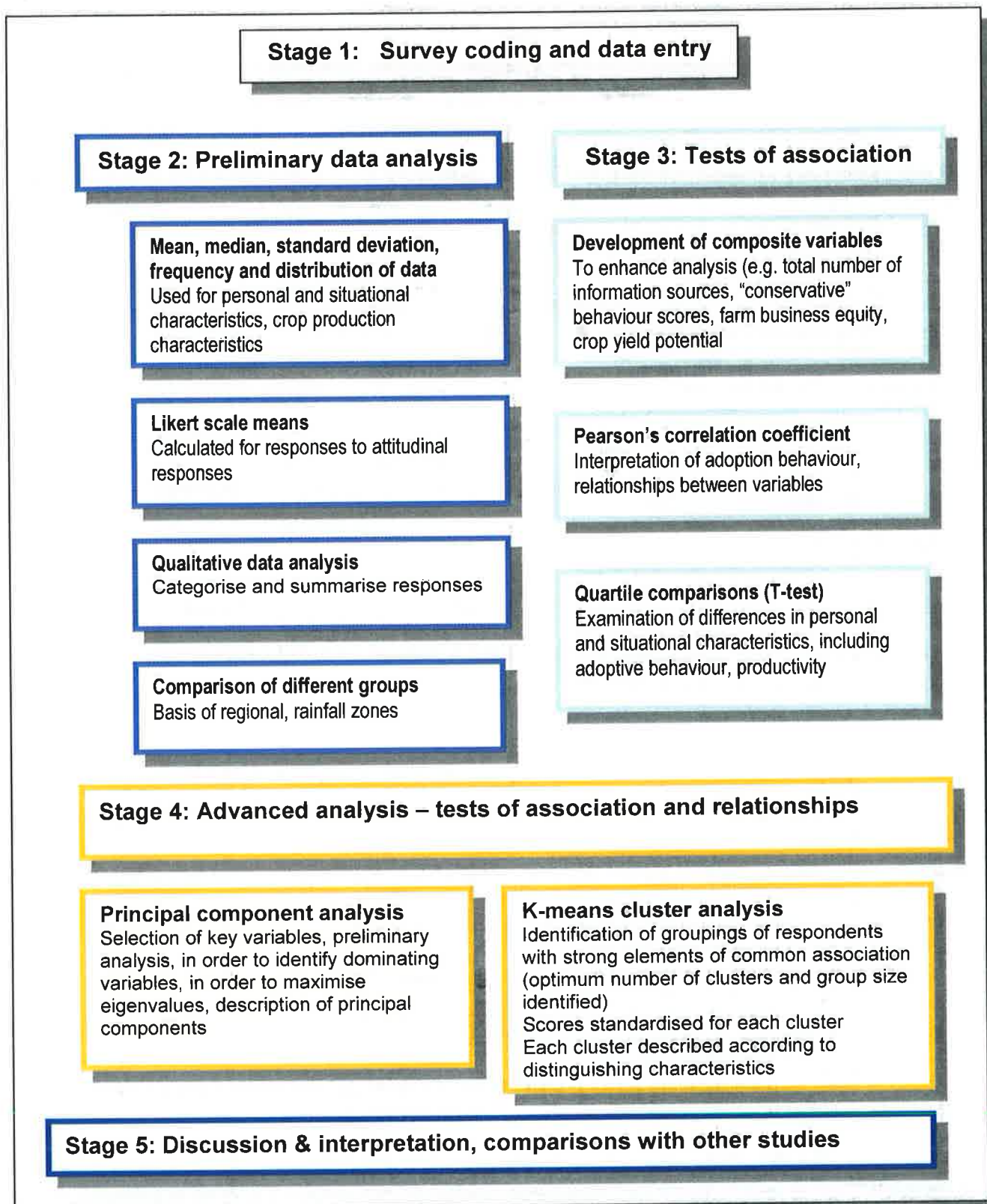
**TABLE 3.4: Summary of data analysis tools utilised in the research project.**

<b>Statistical function</b>	<b>Statistical test used</b>
Statistical summaries	Mean Median values Quartiles
Measurements of dispersion	Standard deviation Range Variance Co-efficient of variation
Correlation	Pearson's correlation coefficient multiple regression
Distribution	Chi-square tests Analysis of variance (ANOVA)
Multivariate analysis	Principal component analysis K-means cluster analysis

### **3.2.2.1 Correlation analysis**

To complete the first stage of correlation analysis all variables that were either continuous, or where the answers had been ranked categorically were included. Using Pearsons' correlation coefficient all correlations were produced in order to ensure maximum possible degrees of freedom. This analysis helped describe the degree to which two variables were linearly related, useful in identifying associations between variables (and groupings of variables) having a common association. Given the large number of observations it was easy for correlations to be significant, caution was exercised during the interpretive phases.

FIGURE 3.4 Overview of data analysis framework utilised



### **3.2.2.2 Analysis of variance**

Analysis of variance was used in to identify differences in continuous or ranked variables between specific groups. In this manner variables were compared across regions in order to identify any statistically significant differences. This analysis was primarily utilised for qualitative based information that was returned to participants attending the focus group workshops. This provided the opportunity to interpret information from the survey that was quantitative in nature.

### **3.2.2.3 Principal component analysis (PCA)**

The principal component analysis (PCA) aimed to define the underlying structure in a data matrix (for the purpose of data reduction (Vidal et al. 2005)). PCA was considered a useful technique used to help bring about better understanding of the relationships between variables within a large data set, and the reasons for variability.

PCA is described as a variable reduction procedure in which the total number of observed variables are reduced to a smaller number of principal components (or artificial variables). The collection of a large number of variables from survey questionnaires can be cumbersome. According to Rowan et al. (1994) difficulties are associated with standard regression analysis, due to the high correlations between variables. PCA helps to address these issues into new sub-sets of unobserved variables, which are described as uncorrelated linear combinations of components or factors.

The PCA process involved taking a number of independent variables and condensing the information contained in them into a smaller data set of uncorrelated variables (on the basis of the correlation structure of the original variables). These are referred to as the principal components. The first principal component is used to account for as much variability in the data set as possible. The variance contained in this principal component is called an eigenvalue. Each succeeding component accounts for as much

of the remaining variability as possible, as the principal components are completely uncorrelated with each other (Lesschen et al. 2005).

In general it is only the first few principal components that are used in describing the variability in the data set. The number of components retained in the analysis depends upon the percentage of variance accounted for by each component (eigenvalues of 1.0 or greater are retained (Broschat 1979)) in order to interpret the components in a meaningful manner (Shinns and Lyne 2003). Interpretation of the principal components can be a subjective activity since there is no mathematical basis for it. Each principal component arising from the analysis is described according to the amount that each of the original variables contributes to it.

PCA was carried out on the data set arising from the survey. Only those respondents that had a full data set (relating to the variables used in the analysis) were included in the analysis that involved a total of 1128 survey respondents. The PCA process did not identify specific groupings of respondents but provided an indication of the collective groupings of underlying variables that brought about population variability. The first procedure was to standardise the data in order to reduce bias due to the different magnitudes and variances of the variables used in the PCA. It was important to ensure that variables used in the PCA had not been derived from other variables included in the PCA (creating a doubling up effect that would result in pronounced relationships between variables due to their derivative association). From the standardised data a matrix of simple correlations between all possible pairs of variables were produced. From this correlation matrix the variables were then transformed into principal components.

PCA runs were conducted in order to develop an integrated assessment of the data and the specific results that were produced through this technique. This was used as a learning exercise in order to gain

a feel for the process and for the data set. Initially as many variables as possible were included in the analysis. This proved difficult in terms of the ability to adequately interpret the results, particularly when many of the variables were similar in their nature of measurement.

In all there were five PCA's carried out. One of the PCA's was selected on the basis of providing highest eigenvalues (ability to explain variability in the data set). This principal component had fewer variables in the analysis but was capable of representing the major variables examined in the study.

#### **3.2.2.4 K-means cluster analysis**

Cluster analysis is a general term that refers to a group of multi-variate statistical methods used primarily in social research. Cluster analysis was used to place survey respondents into specific clusters based upon the characteristics associated with those respondents (Emtage and Suh 2006) and as such acts in the construction of typologies. Cluster analysis is used to identify groupings that are closest to one another (having a strong degree of association) based upon variables used in the analysis.

Specific variables selected for the cluster analysis were guided by the results from the PCA and were supported by the conceptual models developed in the thesis. This is an important process in order to ensure the researcher practices an appropriate level of discretion. According to Bernhardt et al. (1996) the stronger the conceptual framework the greater is the opportunity for the cluster groupings to appropriately identify the distinguishing characteristics associated with each of the clusters.

The cluster analysis procedure adopted was the k-means analysis, and is considered a useful procedure for handling large data sets. As part of the statistical procedure eigenvalues from the PCA were converted into standardised scores for each survey participant. This process provided the ability to

identify the degree to which the population was to be segmented. A cluster analysis was developed based upon the outcomes of the PCA utilising the following approach;

1. The mean value of each variable was subtracted from each respondent's variable score.
2. The differences were divided by the standard deviation for this variable.
3. This standardised value was multiplied by the value of the particular variable in the eigenvector.
4. The sum of numbers was obtained for each variable within the eigenvector/principal component.

The cluster analysis identified specific groupings within the data set that provided the basis for valid comparison. This assisted in identifying the main differences and characteristics between groupings.

### **3.3 SUMMARY**

This chapter has provided details in relation to the characteristics of the study area, in terms of general agricultural production characteristics, soil and rainfall information. Information in relation to the specific research methodologies utilised in this study were then described in detail, and the justification for adopting such a research approach.

Specific information relating to the construction of the survey questionnaire and the importance of pre-testing the survey as a technique for gathering meaningful information associated with the target population was described.

The complexities of data analysis, and the need to develop a methodology that would address the research hypothesis were presented. The use of descriptive and multivariate analysis tools were described in order to provide meaningful representations of a complex data set involving many intervening variables associated with the research population, in addition to the complementarity gained through utilising both quantitative and qualitative data collection approaches.

In Chapter four, a detailed presentation of results originating from the survey questionnaire (covering selected descriptive characteristics of the research population) will be provided. This will be preceded by an analysis of the differential attributes of the survey population (identified through multi-variate analysis of data) and will assist in building the profile of adoption behaviour of the research population in response to addressing the research questions and hypothesis associated with this study.

## **Chapter Four**

### **RESULTS AND ANALYSIS**

This chapter provides a presentation and analysis of results that have a direct relevance to the research questions, conceptual model and hypotheses associated with this study. Information presented is primarily quantitative in nature, providing data that will help to build a better understanding of adoption processes, the nature of agricultural knowledge systems and the characteristics associated with the sample population.

#### **OVERVIEW**

The chapter is divided into eight sections, with each section representing results from either a defined area of the research methodology or an area of specific data analysis. Presented are key findings from the analysis that are considered to address the research questions and hypothesis. Additional information relating to detailed results from a range of analysis that supports the outcomes and discussion associated with the thesis are presented in the appendices.

The first four sections of this chapter provide a summary of results relating to personal characteristics. Section 1 relates to the situational characteristics; section 2 characteristics associated with agricultural knowledge systems; section 3 the nature of innovation processes and section 4 adoption characteristics. In each of these sections, in most instances mean, medium and standard deviation values have been calculated for each variable, in addition to an examination of data distribution characteristics.

The last four sections provide an in-depth look at the data generated through multivariate analysis, providing a strong foundation for the identification and discussion of relationships between variables measured, and interpretation of the adoption characteristics of the survey population. Section 5 provides

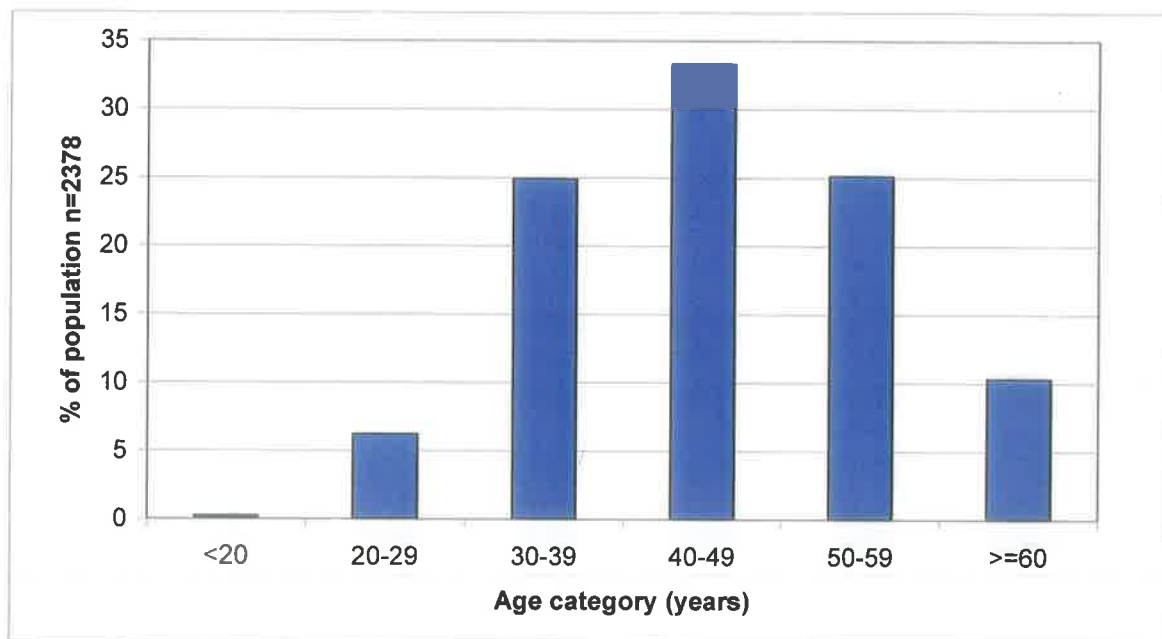
information relating to the differential attributes of the target population; section 6 a comparison of measured variables across survey population segments, section 7 focuses on principal component analysis whilst section 8 identifies the characteristics associated with a range of cluster groupings. Finally a comparison of research approaches and discussion summarise the key findings.

## 4.1 PERSONAL CHARACTERISTICS

### 4.1.1 Age

The age profile of respondents is presented in Figure 4.1, with results indicating that most respondents (33.3%) fell into the 40-49 year age bracket. Some 6.4% of respondents were aged less than 29 years, 24.9% aged between 30-39 years, 25.1% aged 50-59 years and 10.3% aged 60 years or older (n=2378).

**FIGURE 4.1: Categorical representation of the age of survey respondents**

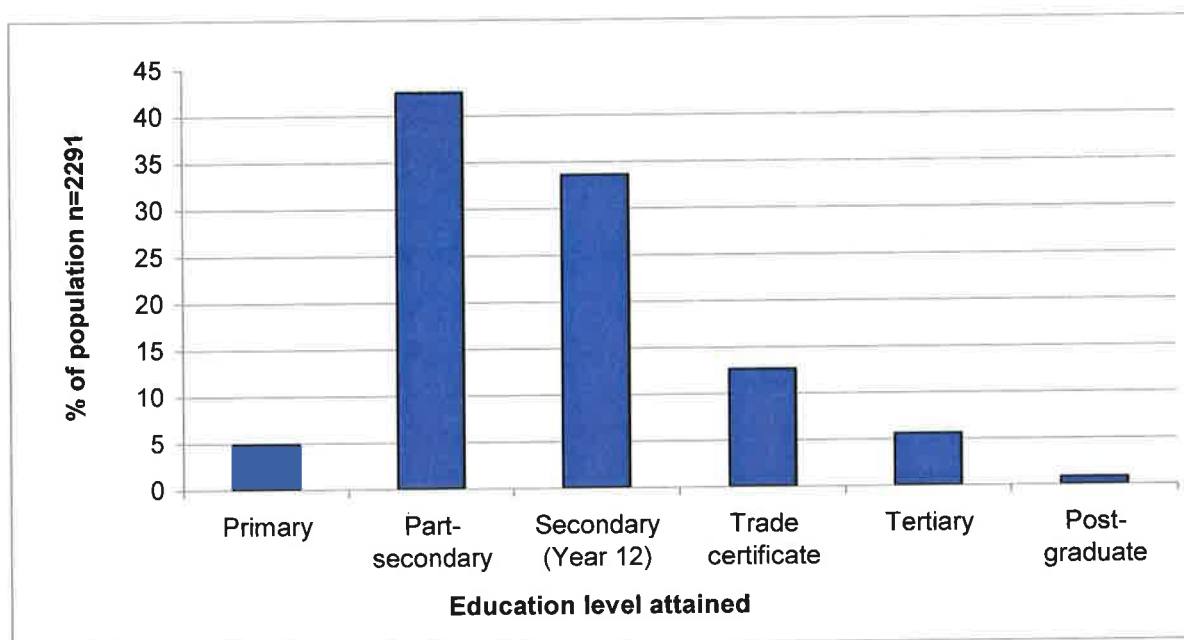


### 4.1.2 Education

Results indicating the highest level of education that had been achieved by survey respondents are presented in Figure 4.2. The majority of respondents (42.5%) had completed only part of their

secondary schooling. Few respondents (6.4%) had a recognised tertiary education qualification (either undergraduate or post-graduate qualifications). Those having trade certificate qualifications accounted for 12.8% of the population whilst 4.9% had only completed a level equivalent to primary school.

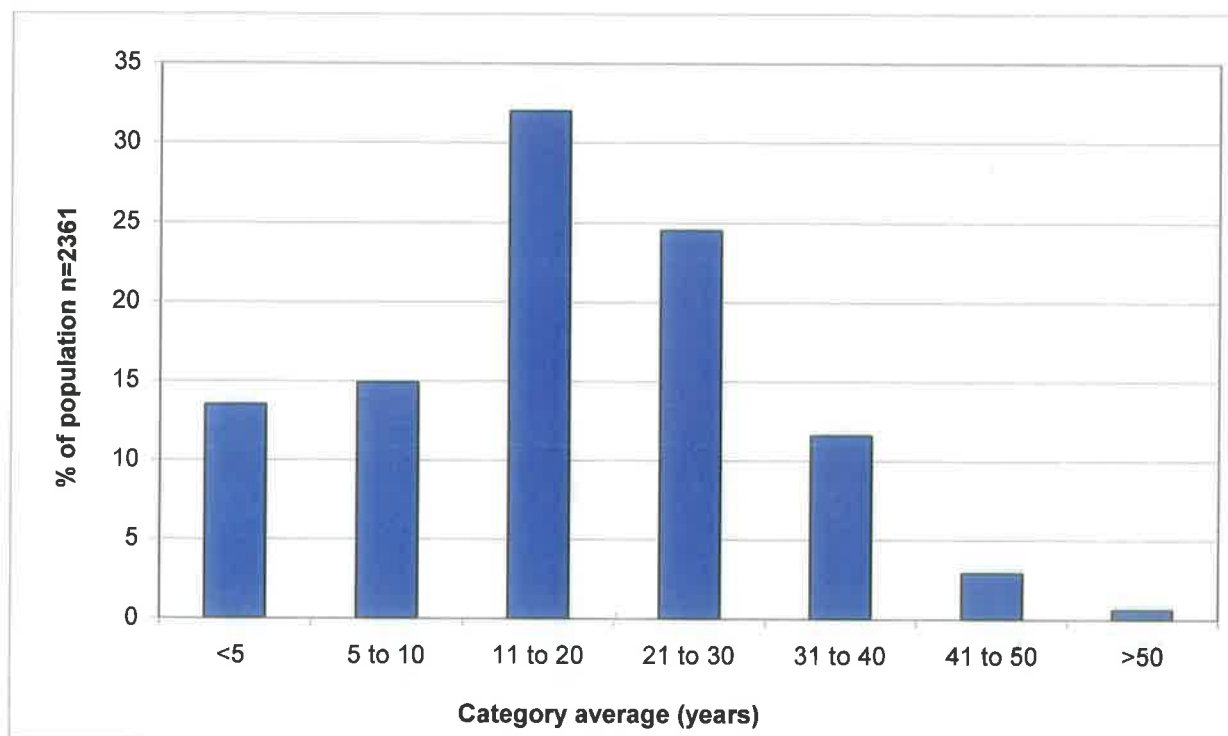
**FIGURE 4.2 Summary of highest level of education achieved by survey respondents**



#### 4.1.3 Farm Management Experience

Results summarising the length of farm management experience held by respondents are presented in Figure 4.3. Results show that 13.5% of the population have less than 5 years farm management experience, 15.0% between 5 and 10 years, 32.0% between 11 and 20 years, 24.5% between 21 and 30 years, 11.6% between 31 and 40 years, 2.9% between 41 and 50 years, and 0.6% greater than 50 years.

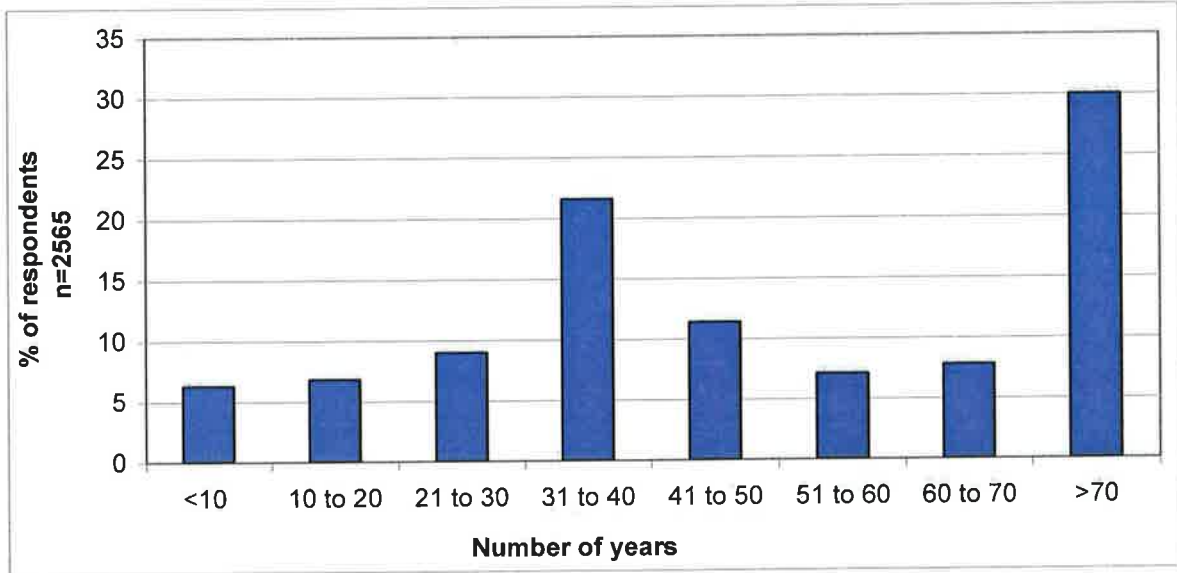
**FIGURE 4.3: Length of farm management experience amongst survey respondents**



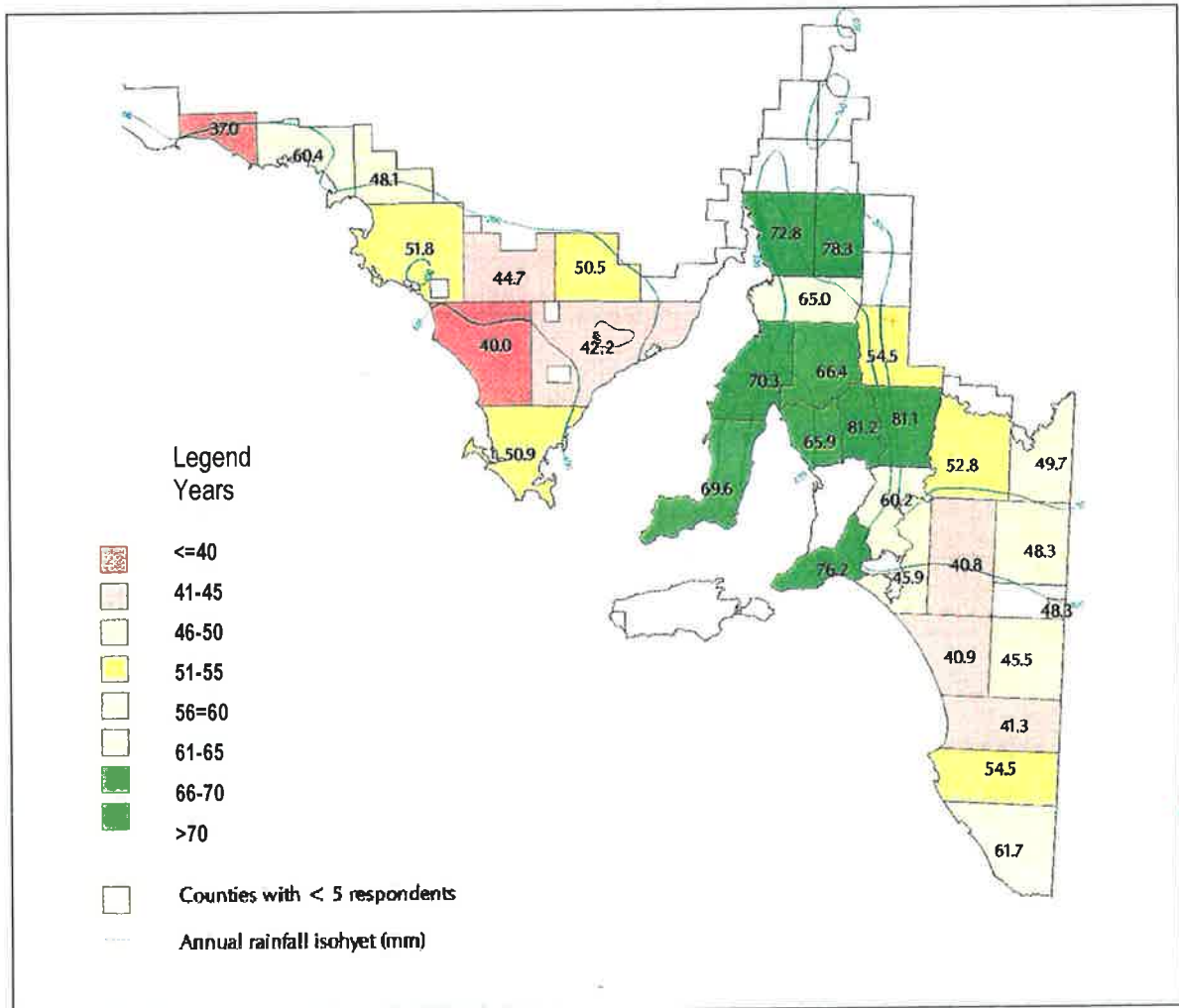
#### **4.1.4 Farm ownership**

In this survey sample, results indicate that 99% of all farming properties were managed as a family business, with less than 1% managed by non-owners, from a total of 2297 survey respondents. In terms of the length of ownership (the number of years that the farming property had been in the family), the highest frequency recorded was for the range greater than 70 years, comprising 34% of survey respondents (Figure 4.4). The second largest category of ownership was 31 to 40 years, accounting for 21.6% of all respondents. Respondents owning their family property for less than 10 years accounted for only 6.3% of the population. The length of farm ownership across South Australia (presented on a County basis) is provided in Figure 4.5, indicating that the length of ownership is greatest in the North and Yorke Peninsula regions.

**FIGURE 4.4: Length of farm ownership amongst survey respondents**



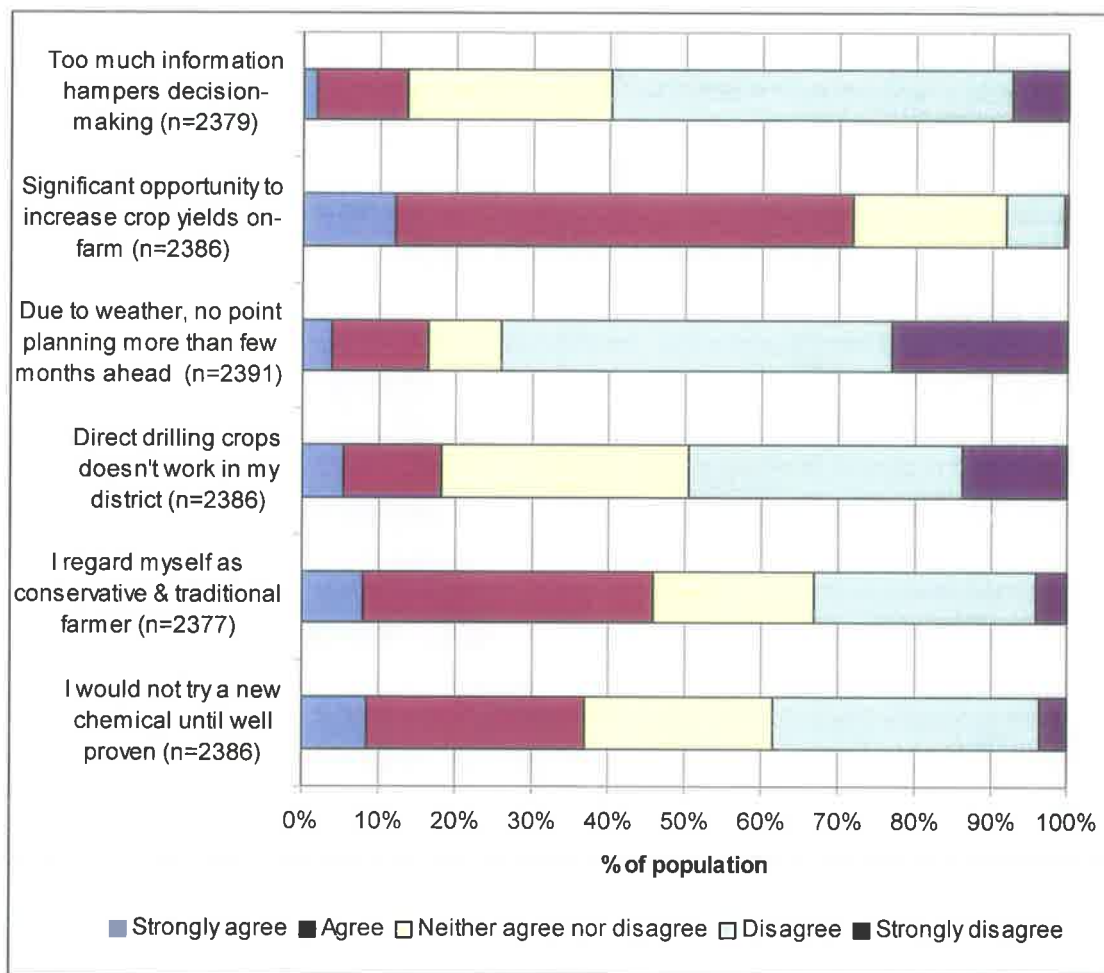
**FIGURE 4.5: Length of farm ownership presented on a county basis**



#### 4.1.5 Attitudes to technology and innovation

Responses were sought in relation to attitudes towards a number of statements associated with the adoption of new technology, conservativeness and personal outlook on farming. Results for a selection of the attitudinal statements are presented in Figure 4.6 (a full presentation of results are provided in Appendix E).

**FIGURE 4.6 Summary of responses to a selected number of attitudinal statements associated with agricultural technology adoption and innovativeness.**

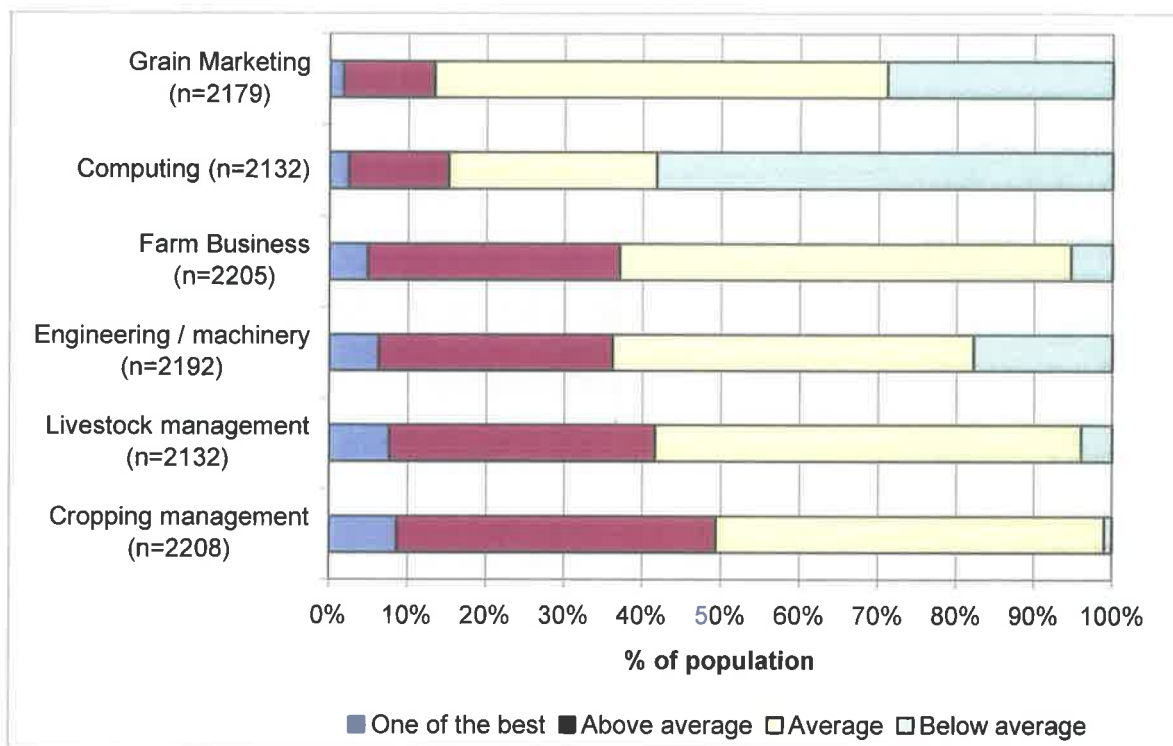


Responses to the attitudinal statements suggest that the farming population remain conservative and traditional in their approach to farming as a result of their response to '*I regard myself as a conservative and traditional farmer*', with 46% of respondents agreeing to this statement (either strongly agree or agree). Some 71.9% of respondents agree or strongly agree to the statement that '*there is significant opportunity to increase crop yields on my farm.*' In general respondents consider that there is an opportunity to significantly increase crop yields on their farms, and regard themselves conservative towards their management and adoption of new farming practices.

#### **4.1.6 Personal Skills**

Respondents rated a number of their own farming skills in comparison to other farmers within their district. Results indicate that farmers are least confident in their level of skills relating to computing (58% consider that they have below average skill levels), followed by grain marketing (38% consider that they have below average skills). Farmers are most confident in relation to their level of skills related to cropping management and livestock management (49% and 42% respectively consider that they are either one of the best or above average skill levels). Summaries of results are provided in Figure 4.7 (with full details presented in Appendix F).

**FIGURE 4.7: Personal skills assessment for respondents**

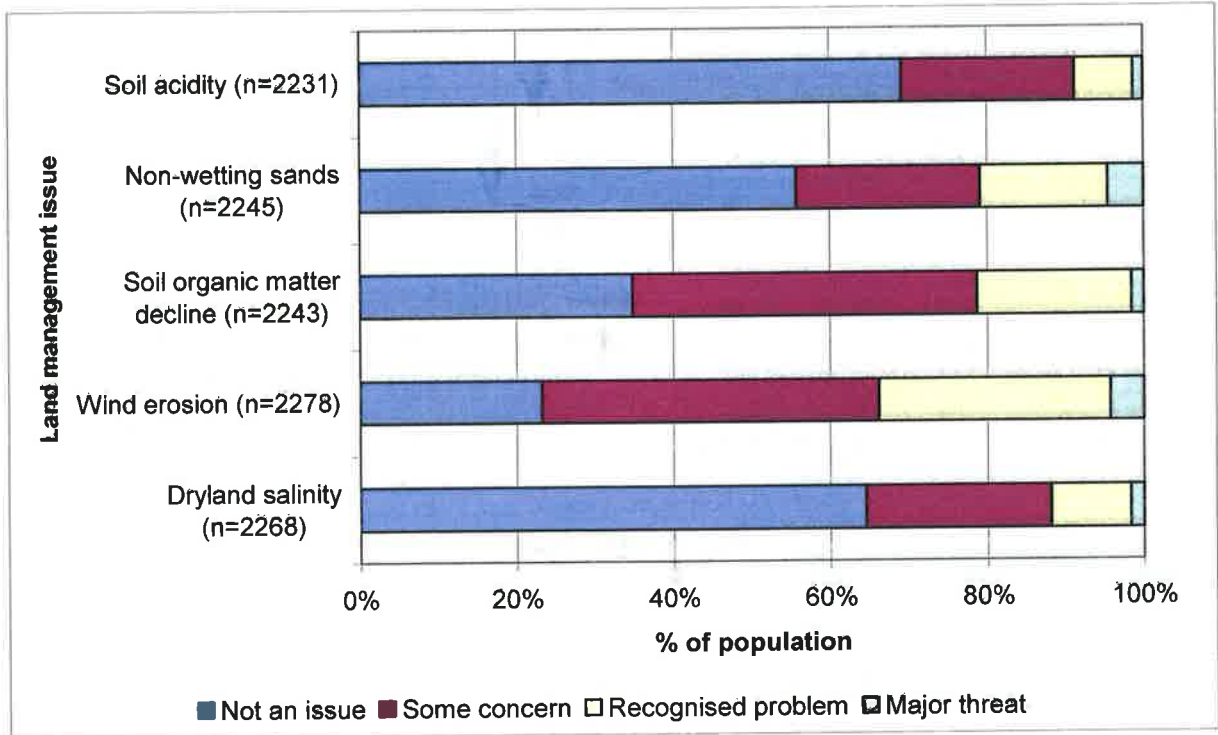


#### 4.1.7 Soil and land management concerns

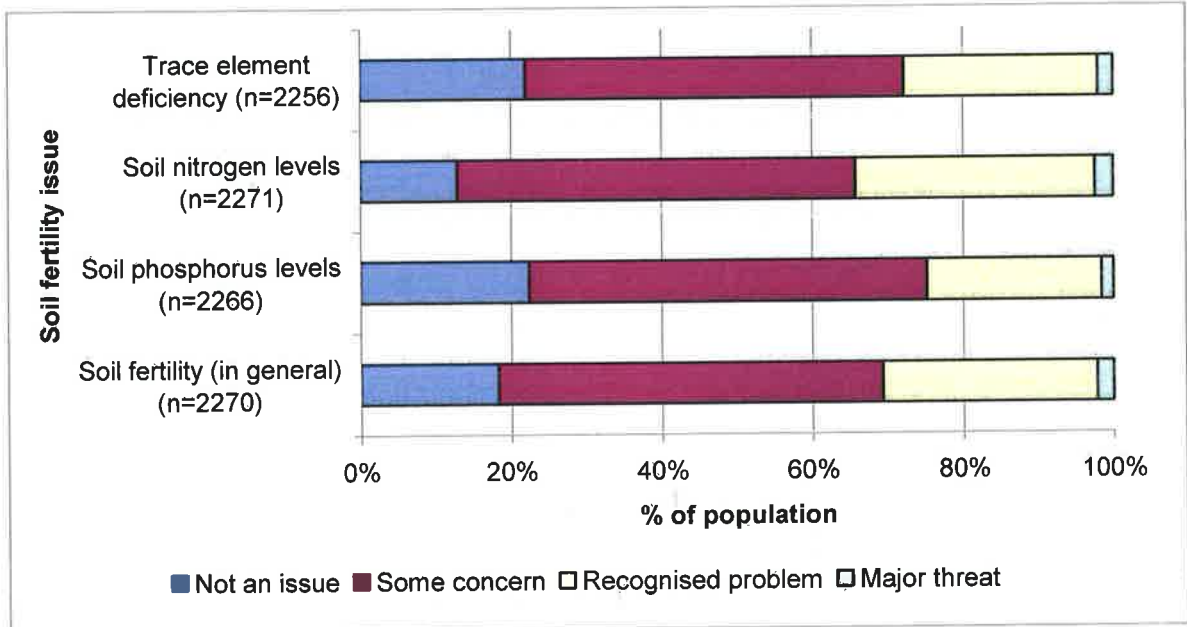
Survey respondents were asked to indicate their level of concern towards a range of land management and soil fertility concerns. The three most important land management issues (in terms of the cumulative score) were wind erosion (33.8%), soil organic matter decline (21.4%) and non-wetting sands (20.9%). Soil acidity (8.8%) and dryland salinity (11.9%) were of least concern to respondents (Figure 4.8).

Soil nitrogen (34.3%) and soil fertility (30.7%) were rated as the two most important soil fertility issues (cumulative score for the categories of either a recognised problem or a major threat), whilst trace element deficiency (27.8%) and soil phosphorus levels (24.8%) were rated as less important (Figure 4.9). A summary of results is presented in Figures 4.8 and 4.9 respectively (with full details presented in Appendix G).

**FIGURE 4.8 Concern towards land management issues from respondents**



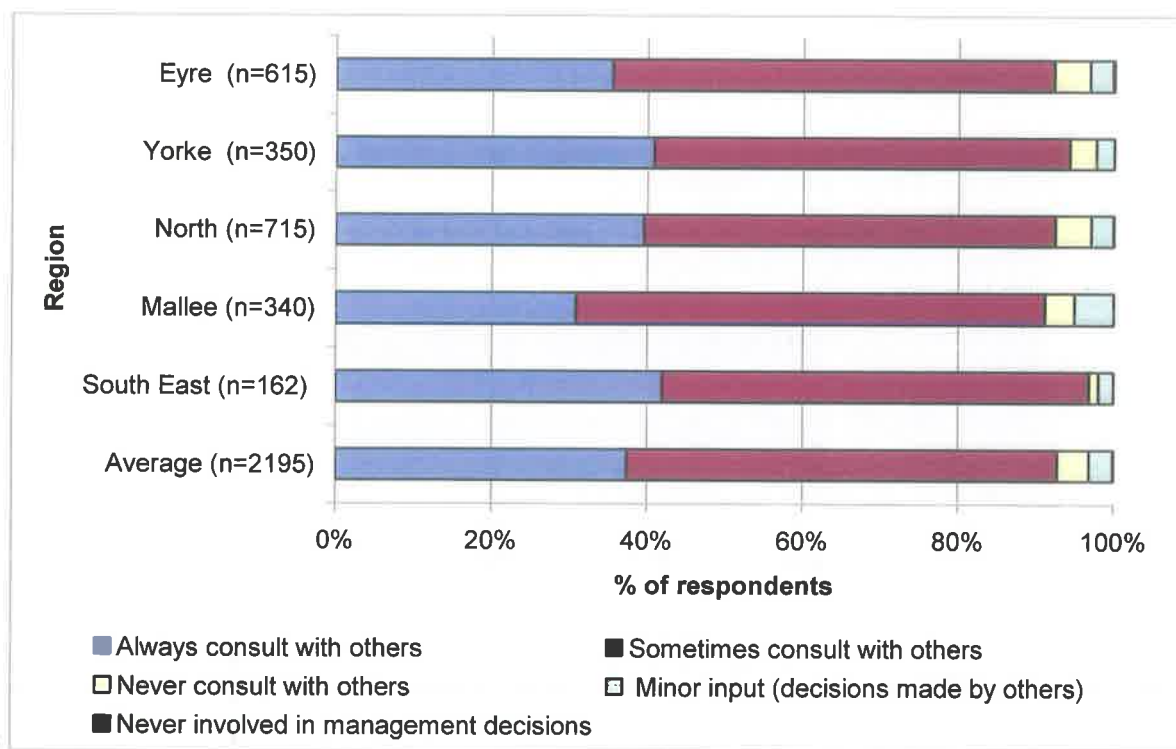
**FIGURE 4.9 Concern towards soil fertility issues from respondents**



### 4.1.8 Farmer decision-making

Results summarising the level of consultation that respondents sought in relation to making on-farm decisions are provided in Figure 4.10 (with a full presentation of results provided in Appendix H). Results indicate that the majority of participants consult either sometimes (55.4%) or always (37.5%) when making on-farm decisions (Figure 4.9). Overall a low number of respondents (4.1%) never consult others and make their decisions in isolation. A further 3% indicated that they sought minor input into decision-making from others. Respondents from the Mallee and Eyre Peninsula (30.9% and 35.6%) are less likely to always consult with others compared with respondents from other regions.

**FIGURE 4.10 Degree of consultation in relation to farm business management decision-making by respondents**

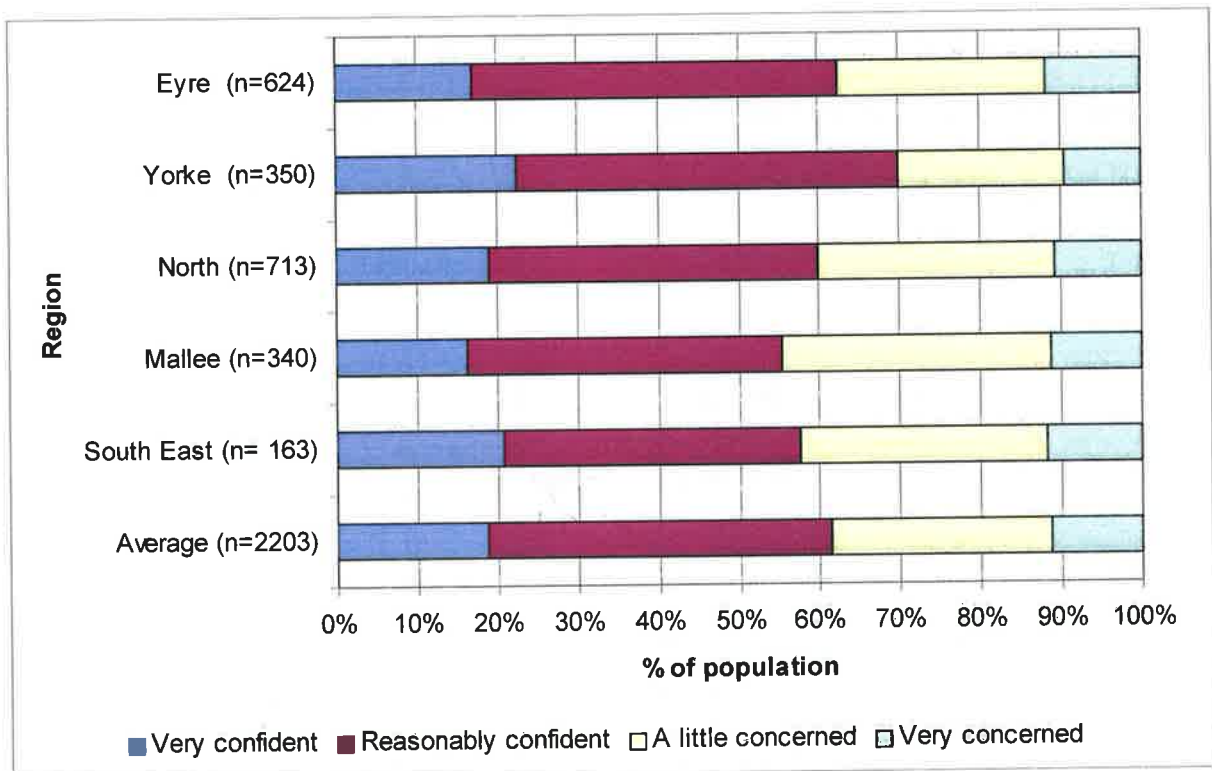


#### 4.1.9 Confidence in long-term financial viability

Respondents were asked to indicate the degree of confidence they held in relation to the long-term financial viability of their farm business. Summaries of these results are presented in Figure 4.11 (with full presentation of results provided in Appendix I).

On average, 61.4% of the respondents were confident of the long-term financial viability associated with their farming business, whilst 38.6% showed varying degrees of concern. There were a number of farmers across the State (11.2%) who indicated that they were very concerned about the future. Farmers from the Mallee were most concerned (44.2% being a little or very concerned) whilst farmers from Yorke Peninsula were least concerned (30.0% being a little or very concerned).

**FIGURE 4.11 Confidence in relation to the long-term financial viability of the farm business**



#### **4.1.10 Summary of personal characteristics**

Results describing the personal characteristics of respondents have provided an overview of the profile of what can be described as “the average farmer” in the target population. These characteristics are summarised in the following text (based on average values for each of the measured variables).

Aged between 40 and 49 years, an education level equivalent to completion of secondary schooling, and have managed their farm business for a period of between 11 and 20 years (following a period of 10 years in a non-management role). Most respondents considered themselves skilled in cropping and livestock management, but felt that they had low levels of skills relating to use of computers and grain marketing. Respondents generally shared their decision-making processes with other family members and held reasonable confidence in the future of farming as a whole. Most survey respondents were conservative in their approach to farming, reflected by their reserved attitudes to new technology and innovation, and rate of adoption of practices, particularly those considered to be more complex and associated with higher elements of risk. The average farmer is also described as being optimistic, with most considering that improvements in crop productivity were possible on their own farm within the next 5 years.

The collection of the personal characteristics associated with the survey population has assisted in providing an understanding of those factors that may be responsible for influencing the adoptive behaviour of the survey population.

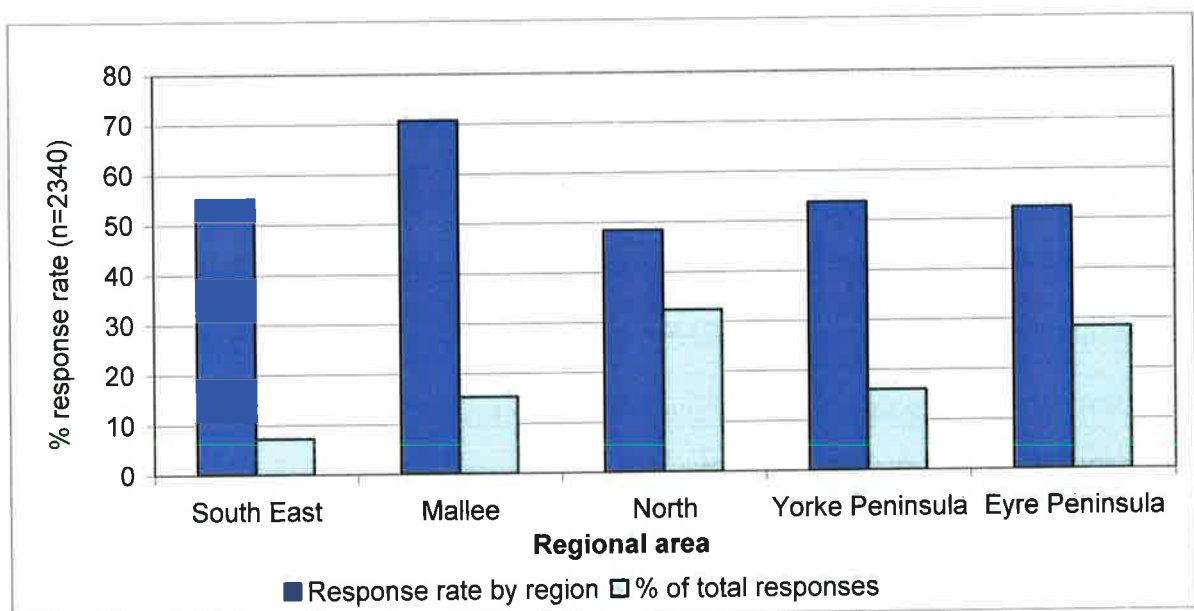
## 4.2 SITUATIONAL CHARACTERISTICS

In this section, a comprehensive presentation of the situational characteristics associated with the environment in which farmers operate is presented, building on the overview of personal characteristics discussed to date. Elements described include farm characteristics (location, rainfall), farm financial indicators (value of assets, farm equity), farm size and productivity characteristics (crop yield, and yield potential achieved).

### 4.2.1 Farm location

Information was obtained on the location of the farming land managed by farmers, with respondents indicating Hundred/s in which their land was located. Information was used to carry out further comparisons of data on a district and regional basis, in addition to mapping data on a Hundred and County basis. Figure 3.1 provides an indication of the location of Counties across the agricultural districts of South Australia that were used in the analysis and presentation of results. Figure 4.12 provides a summary of the number of respondents from each region of the State. Response rates from the regions ranged from 48% in the North to 71% in the Mallee.

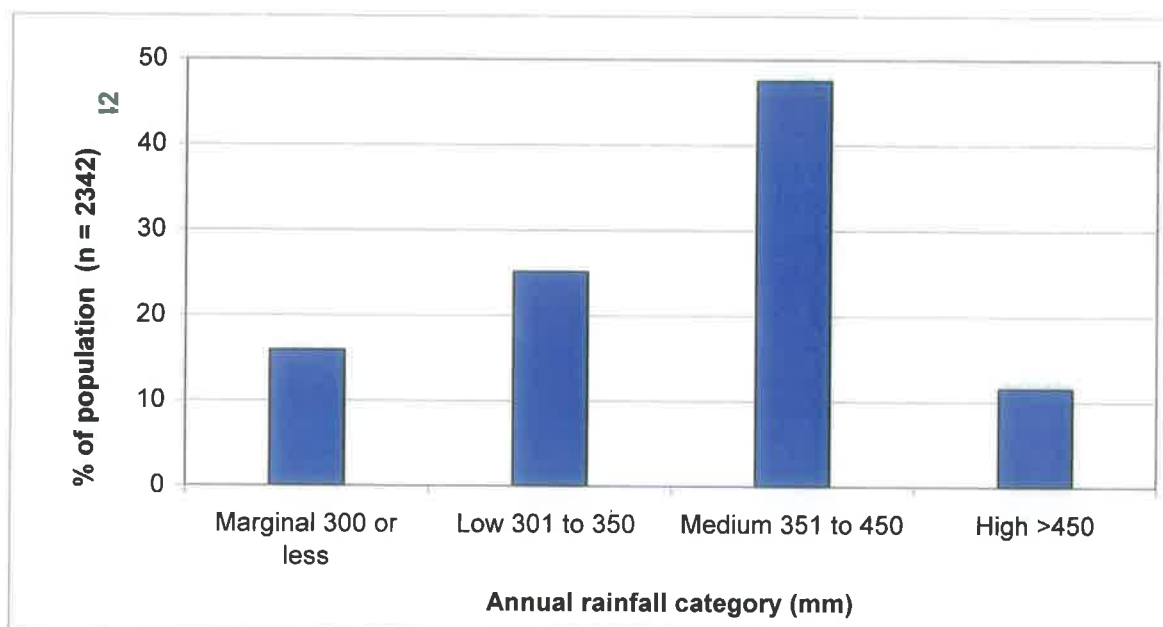
**FIGURE 4.12 Survey response rates from each region**



#### 4.2.2 Annual Rainfall

Results relating to the annual rainfall received on-farm are provided in Figure 4.13. The majority of respondents (47.6%) farmed within an average annual rainfall environment receiving between 351 and 450 mm (medium rainfall), 25.1% between 301 and 350 mm (low rainfall), 15.9% receiving 300mm or less (marginal rainfall) and 11.5% in excess of 450mm (high rainfall).

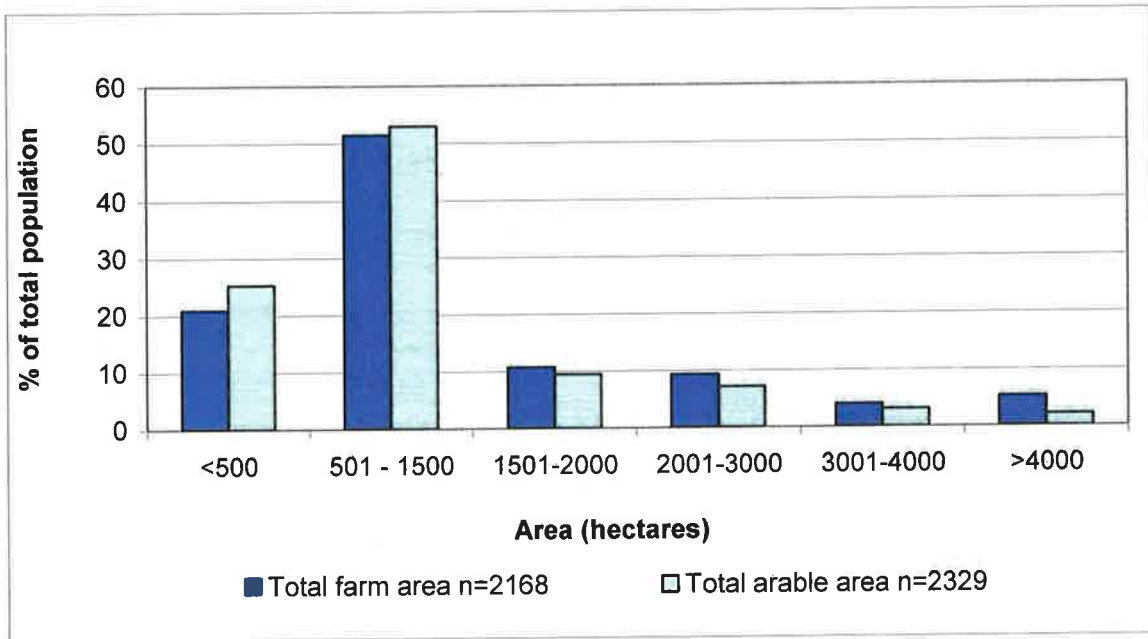
**FIGURE 4.13: Distribution of respondents according to annual rainfall**



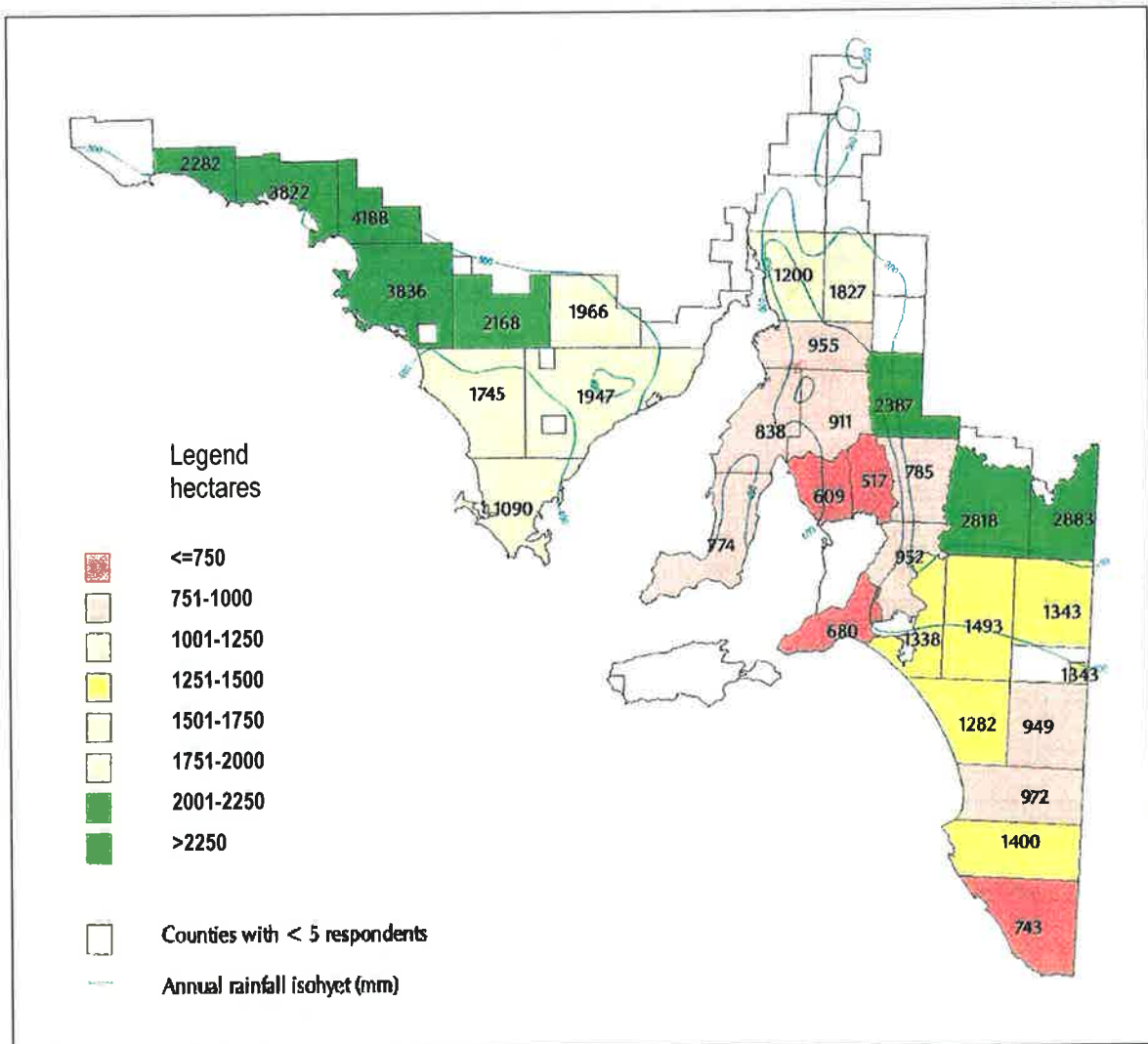
#### 4.2.3 Farm area

Results summarising the average farm area (total arable and non-arable area) are presented in Figure 4.14. Of the survey population 20.9% had a farm area of less than 500 hectares, whilst 18.5% of survey respondents had an area in excess of 2000 hectares. Approximately 53% of the population had a property size in the range of 101 to 1500 hectares. Average farm area represented has been mapped on a County basis (Figure 4.15). It is evident that largest farm sizes are found in the northern Mallee and Eyre Peninsula, with indications that the largest farms are located on western Eyre Peninsula.

**FIGURE 4.14: Total farm area and arable area of survey respondents' farms**



**FIGURE 4.15: Average farm area (hectares) represented on a County basis for SA**



#### 4.2.4 Farm financial indicators

Information was collected from respondents relating to a range of farm financial indicators that included the market value of the farming land, machinery, livestock, and the total amount of farm borrowing (liabilities). Results are presented in Figure 4.16. Indications are that 58.1% of respondents owned farming properties valued at in excess of \$500,000. Some 21.7% of respondents indicated that they were debt free, whilst a further 32.6% of respondents had debts of less than \$100,000, with 35.7% having a debt level in excess of \$100,000.

**FIGURE 4.16 Distribution values for farm assets and borrowings**

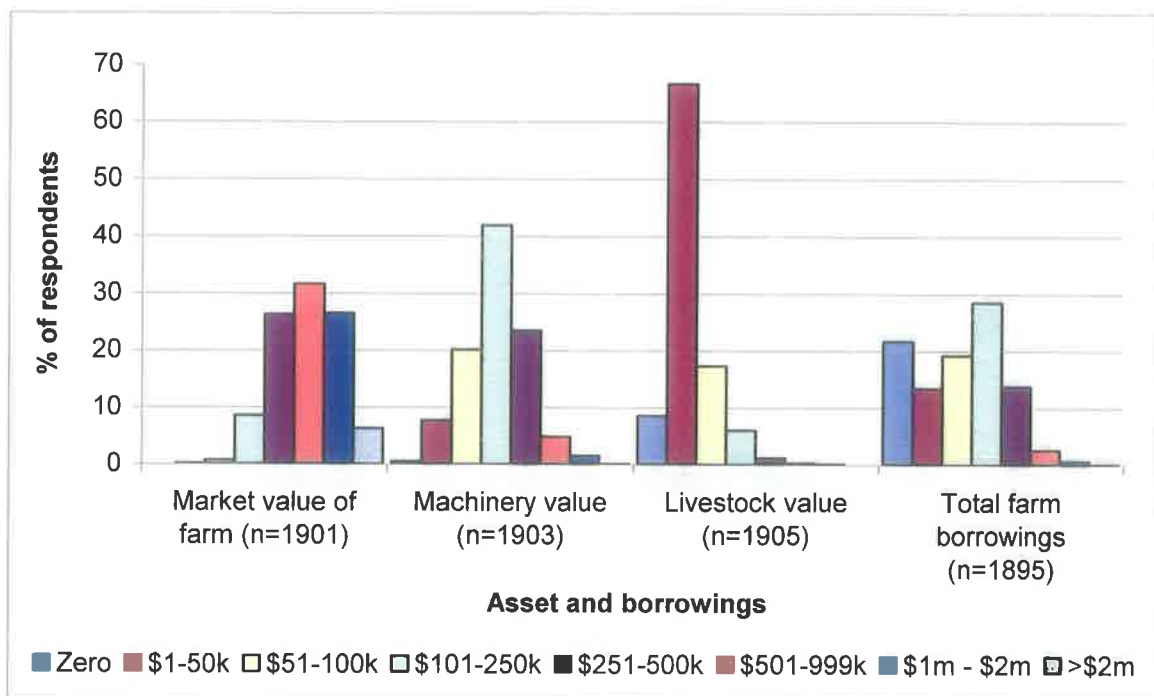
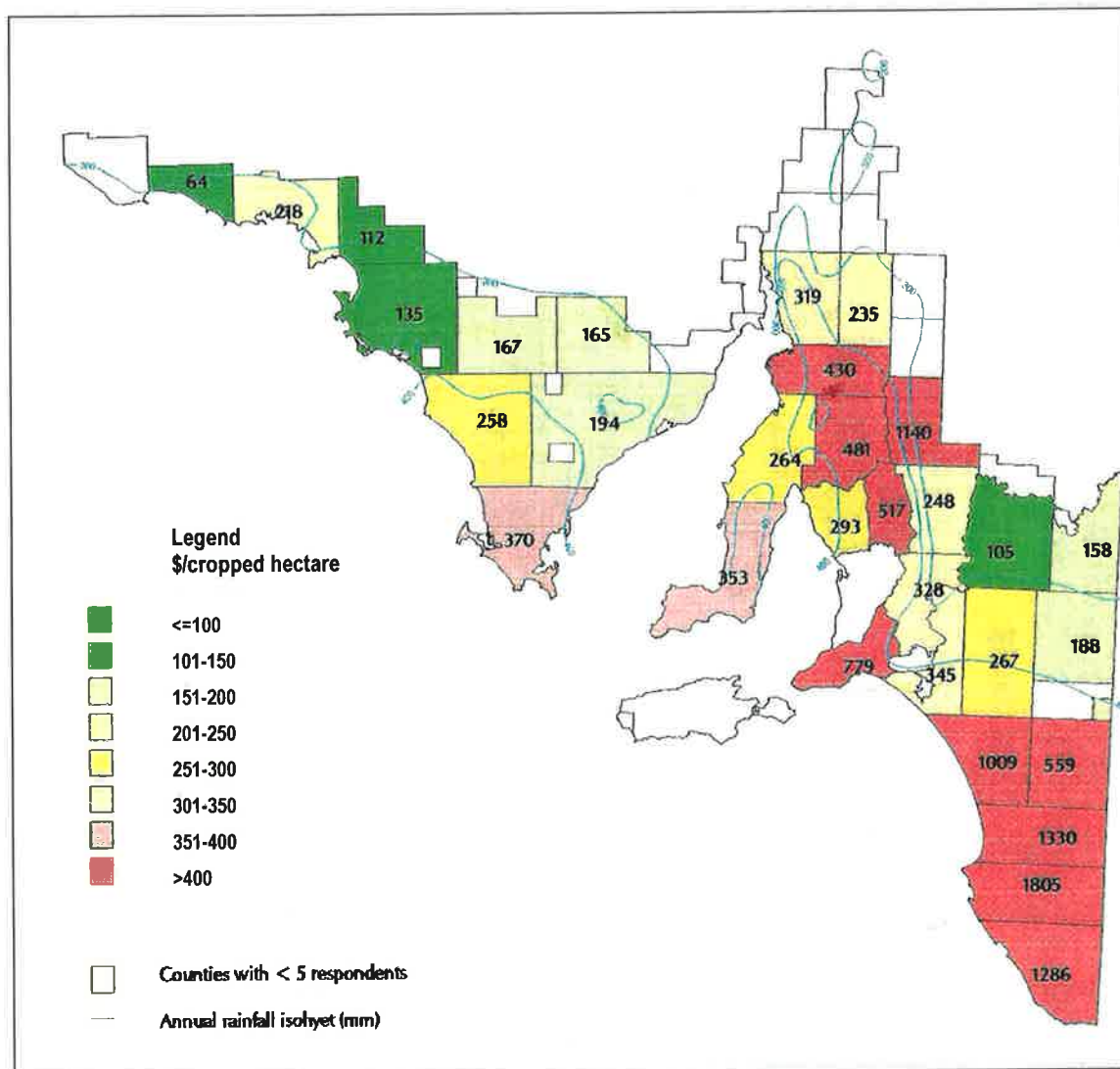


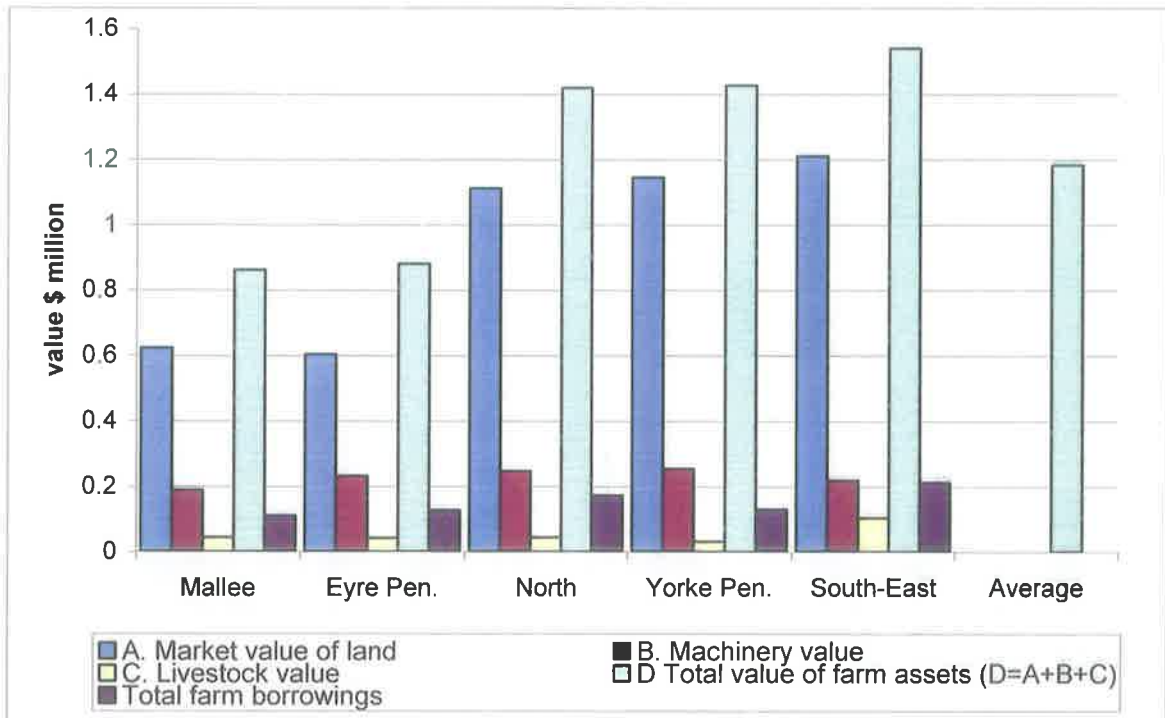
Figure 4.17 provides an indication of the average debt per cropped area (total farm debt divided into number of hectares cropped annually) and is provided on a County basis. Results suggest that there is a greater debt loading in the more reliable cropping regions of the State. This may be reflective of the relative productivity of the land. Lowest debt levels are on Eyre Peninsula and the northern Mallee.

**FIGURE 4.17: Average debt (\$ per cropped hectare) for SA, represented on a County basis**



Information was also presented on a regional basis in terms of the value of farm assets and liabilities as presented in Figure 4.18 (with full details presented in Appendix J). The survey data shows that land values per farming business are lowest on Eyre Peninsula (\$0.6million) and in the Mallee (\$0.62 million) and greatest in the South East (\$1.2 million). The value of machinery associated with each farming business ranged from \$0.19 million in the Mallee up to \$0.26 million on the Yorke Peninsula.

**FIGURE 4.18: Value of farm assets and liabilities represented on a regional basis**



Calculated values for business equity (presented on a regional basis in Figure 4.19 and on a County basis in Figure 4.20) indicate levels ranged from 83.7% on Eyre Peninsula to 89.1% on Yorke Peninsula, with an average value of 85.8% for all respondents. The distributions of equity values for farm businesses are presented in Figure 4.21. Only 12.8% of businesses had an equity value of 65% or less, whilst 35% had equity levels of 95% or higher.

**FIGURE 4.19 Equity levels of farm businesses represented on a regional basis**

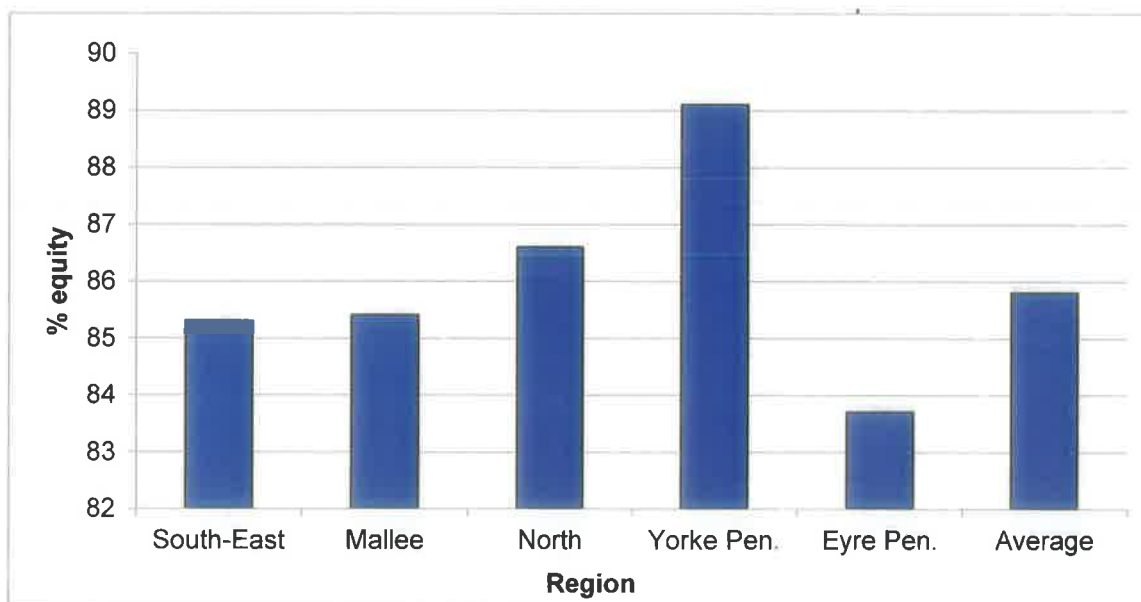


FIGURE 4.20: Farm business equity (%) represented on a County basis for respondents

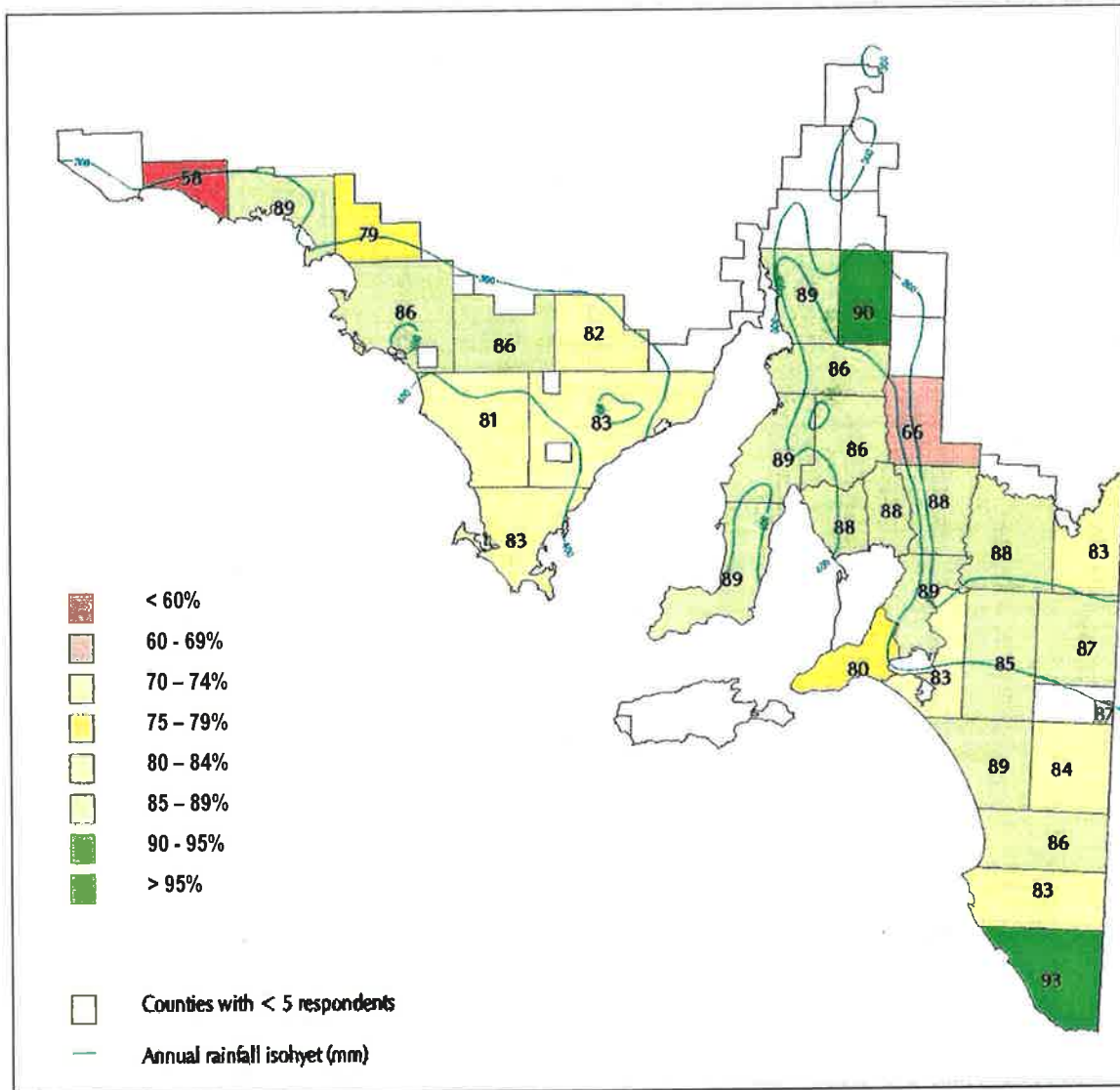
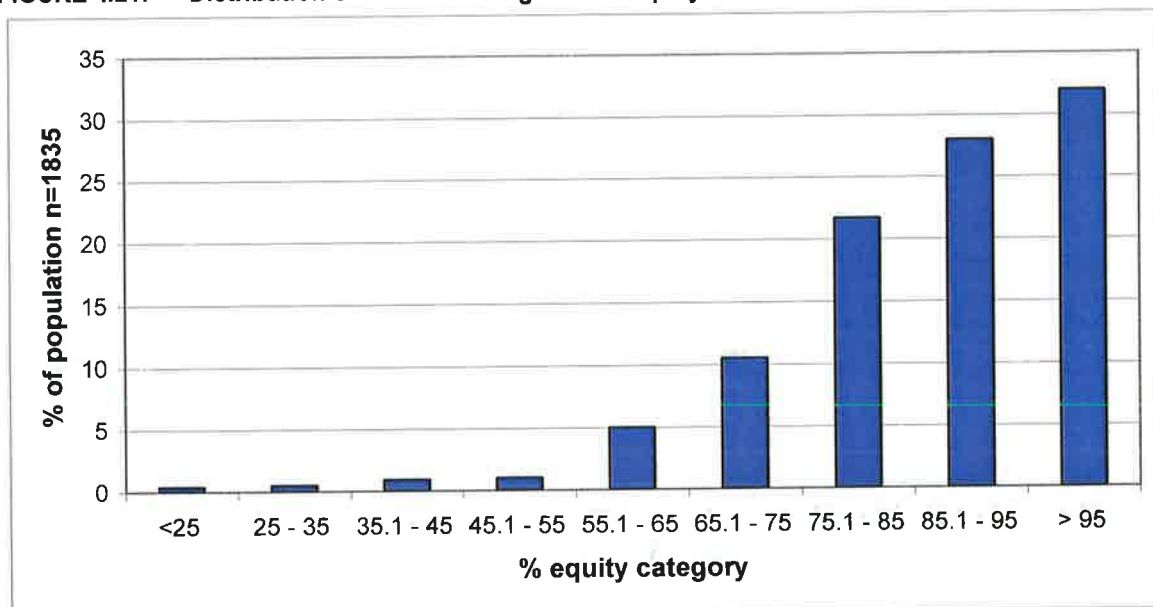


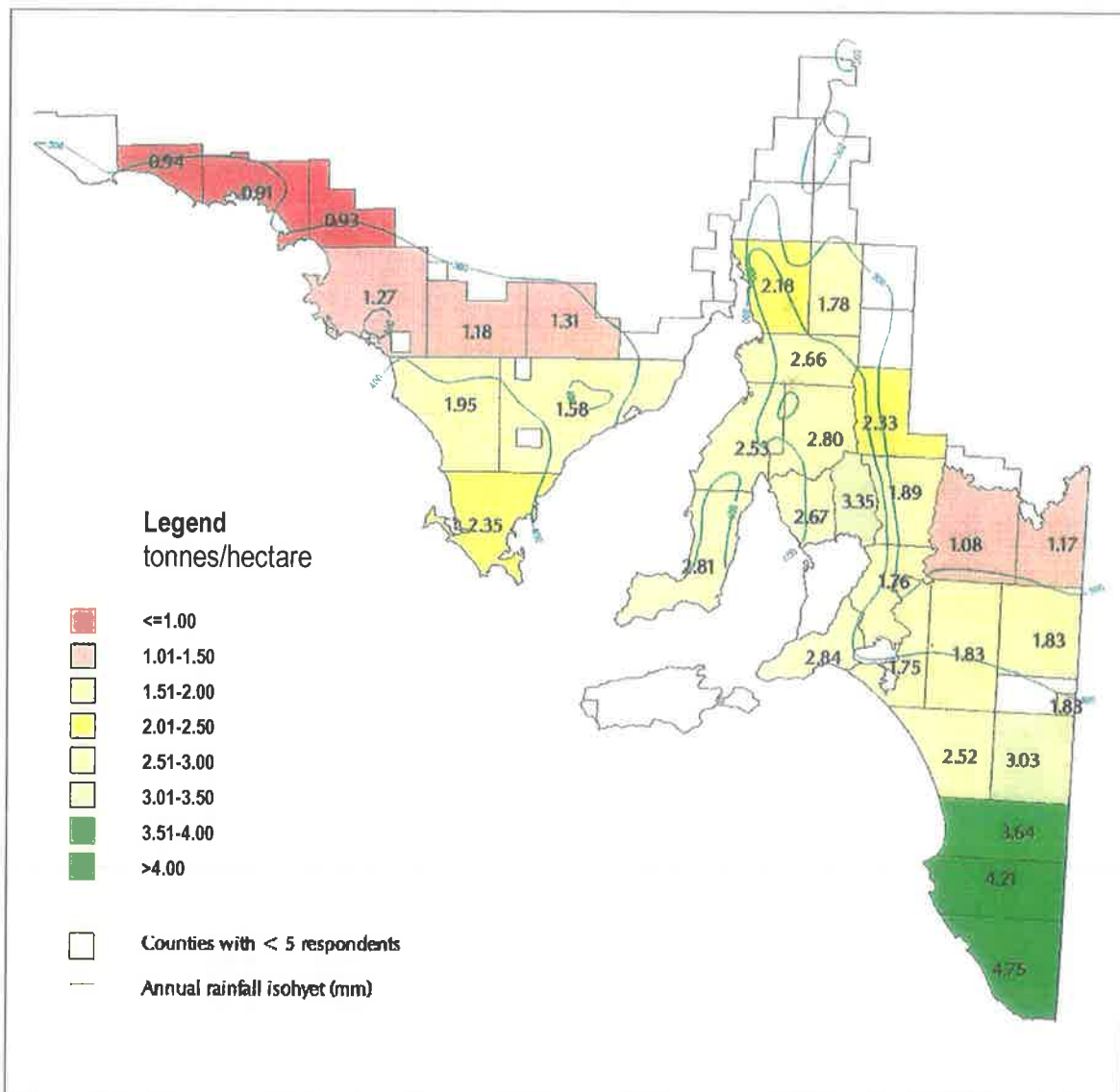
FIGURE 4.21: Distribution of values relating to farm equity values



#### 4.2.5 Productivity characteristics

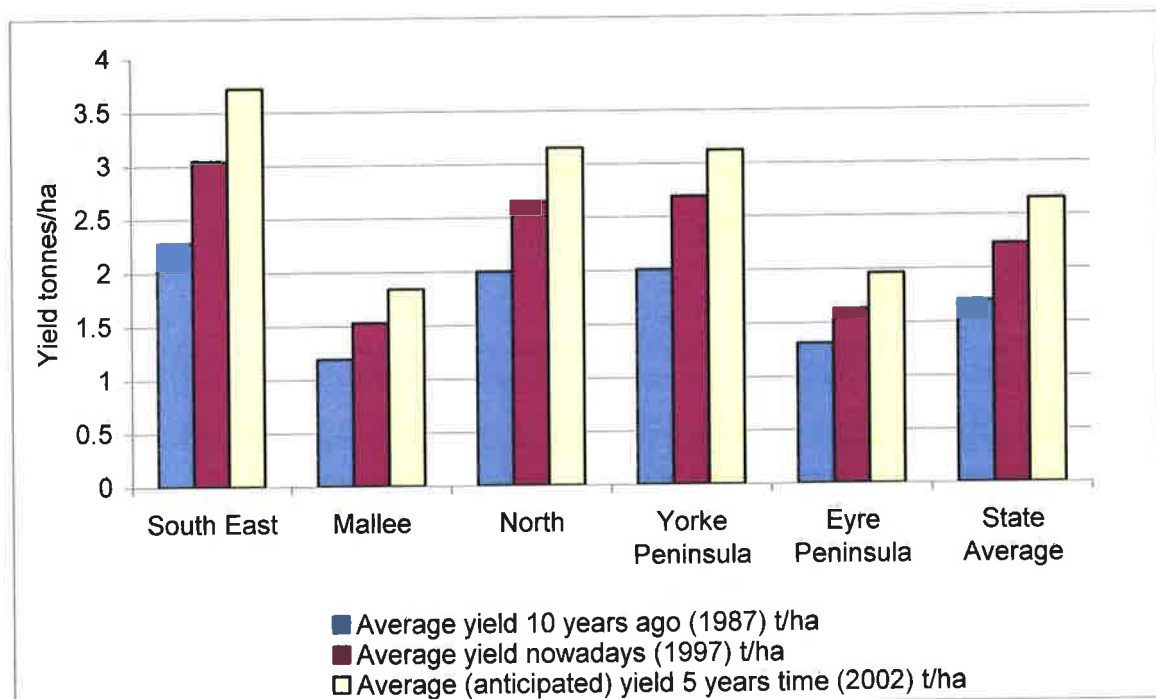
Information was gathered in relation to past and future (anticipated) on-farm crop yields for wheat. This exercise provided an opportunity to assess the impact that past technologies may have had in terms of on-farm yield increases, in addition to gauging industry confidence in terms of the ability to increase crop yield into the future. Using wheat as a specific example from the survey a geographical representation of current (1997) wheat yields (represented on a County basis) were developed (Figure 4.22).

**FIGURE 4.22: Current wheat crop yields (t/ha) represented on a County basis**



Change in crop yields for the period 1987 to 1997, and anticipated yield increases (5 years time to 2002) are presented in Figure 4.23. Results indicated that ten years prior to the 1997 survey (1987) the average crop yield was 1.70 tonnes/hectare. Wheat yields ranged from 1.19 t/ha (Mallee) to 2.28 t/ha (South East). The average wheat yield (1997) indicated by respondents was 2.23 t/ha, with a range of 1.53 t/ha (Mallee) up to 3.04 t/ha (South East). The anticipated State average wheat yield expected by respondents in 2002 was 2.65 t/ha (with a range of 1.84 t/ha (Mallee) to 3.72 t/ha (South East)). Annual wheat yield increases are presented on a County basis in Figure 4.23. Results show the greatest rate of increase is in the South East, Northern and Yorke Peninsula regions. Least gain was expected in the Mallee and Eyre Peninsula.

**FIGURE 4.23 Wheat crop yields (t/ha) past (1987), present (1997) and future (2002)**



Average wheat yield increases experienced between 1987 and 1997 are presented graphically in Figure 4.24, and illustrate differences achieved on a regional basis.

**FIGURE 4.24: Average wheat yield increases (kg/ha/yr) in the period of 1987 to 1997**

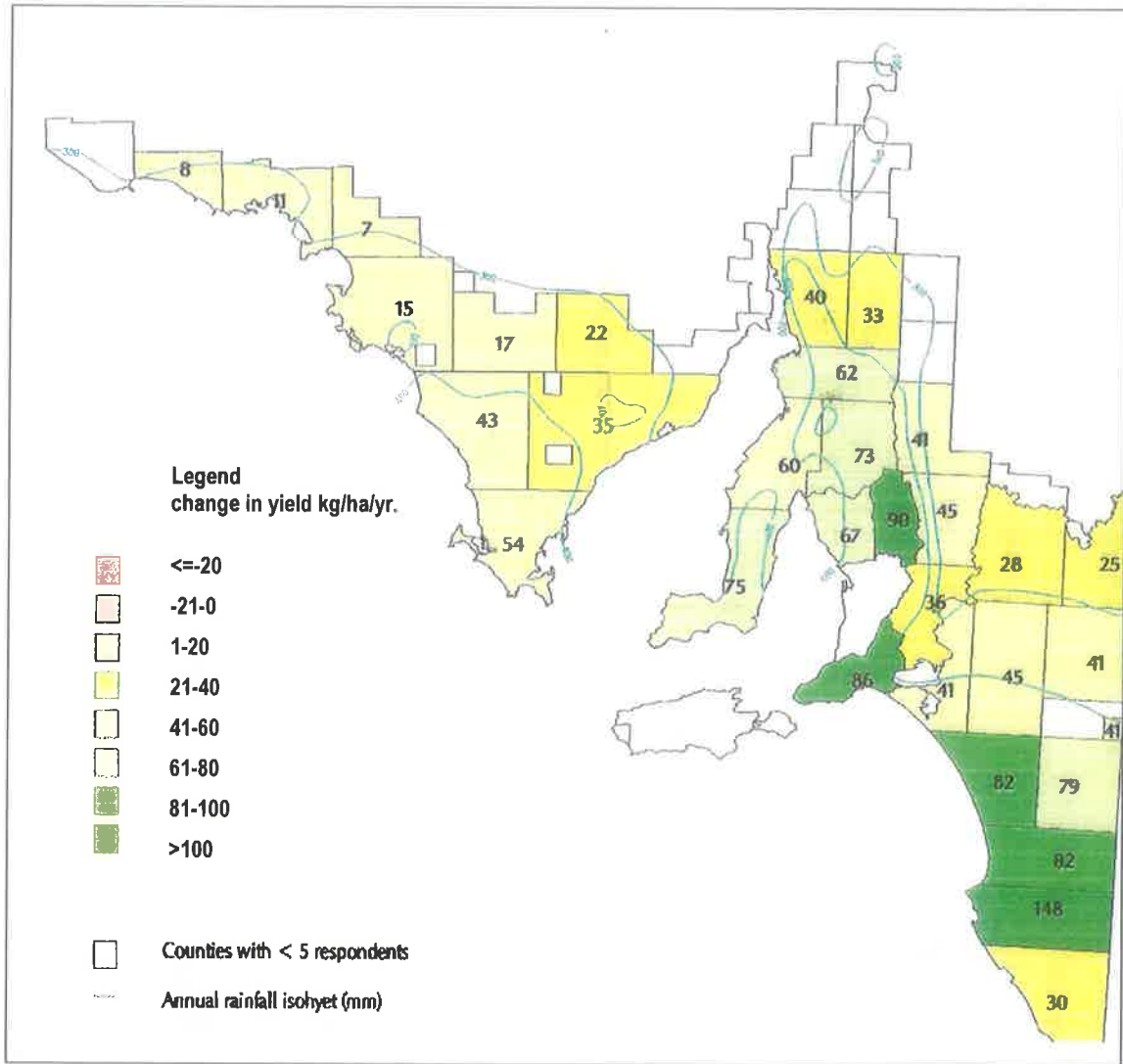
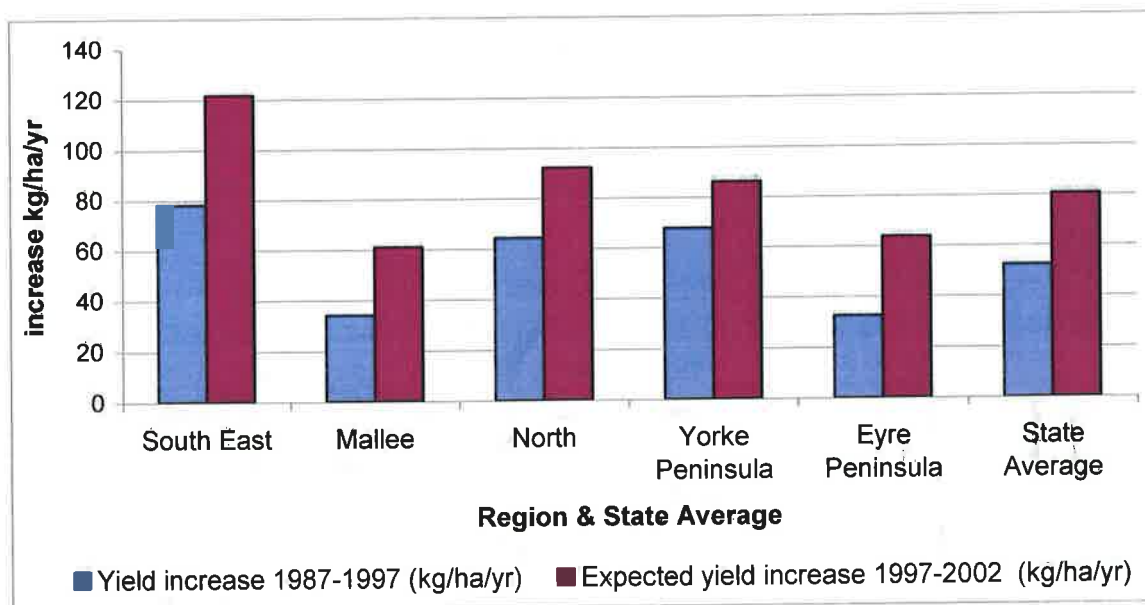


Figure 4.25 provides a summary of the annual wheat yield increase over the period of 1987 to 1997 and the expected yield in 2002 on a regional basis. Similar yield increases are expected for the Mallee and Eyre Peninsula (34.3 and 32.7 kg/ha/yr respectively) whilst the highest increase is indicated in the South East (78.2 kg/ha/yr). Additional information in relation to wheat yield averages and anticipated crop yield increases are provided in Appendix K.

**FIGURE 4.25 Annual wheat yield (kg/ha/yr) increase (1987- 1997), and anticipated increase (1997-2002) for the different regions**

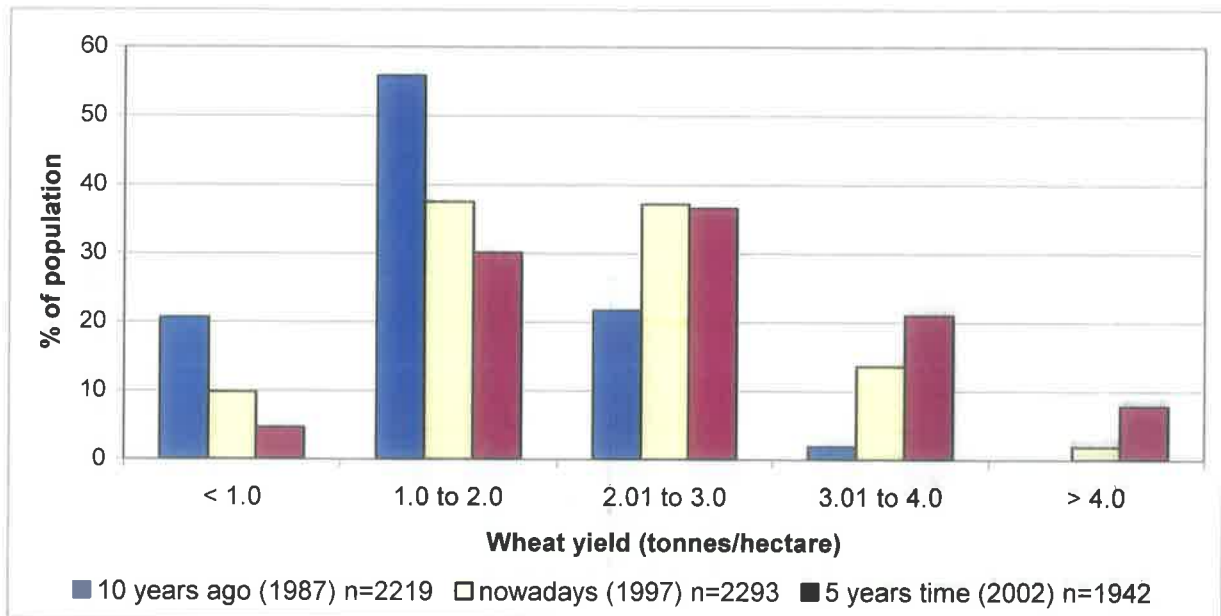


#### 4.2.5.1 Distribution of crop yields

By examining the distribution of crop yields it was possible to identify the shift in crop yields achieved and/or expected by respondents. Information is summarised in Figure 4.26. Ten years ago, 20.6% of the respondents were producing less than 1.0 t/ha. At the time of the survey (1997), 9.8% of the respondents produce less than 1.0t/ha and in 5 years time (as anticipated by respondents) this proportion was expected to drop to 4.6%. A decade ago (1987), 55.8% of respondents considered that their average crop yield was in the order of 1.0 to 2.0 t/ha; now 37.5% were achieving this level of production, and illustrates a positive shift in crop yields achieved by respondents.

Ten years ago only 1.9% of respondents produced between 3.0 and 4.0 t/ha of wheat. In 1997, 13.6% of respondents were achieving crop yields within this range. In 5 years time (2002), 21.0% of respondents were anticipated to be achieving this level of crop yield. By 2002, some 7.8% of respondents anticipated that their average yield would exceed 4.0t/ha, up from 1.9% of respondents as indicated for 1997 and less than 0.1% achieving such yields in 1987.

**FIGURE 4.26: Distribution of wheat yields (t/ha) in the period 1987-2002**



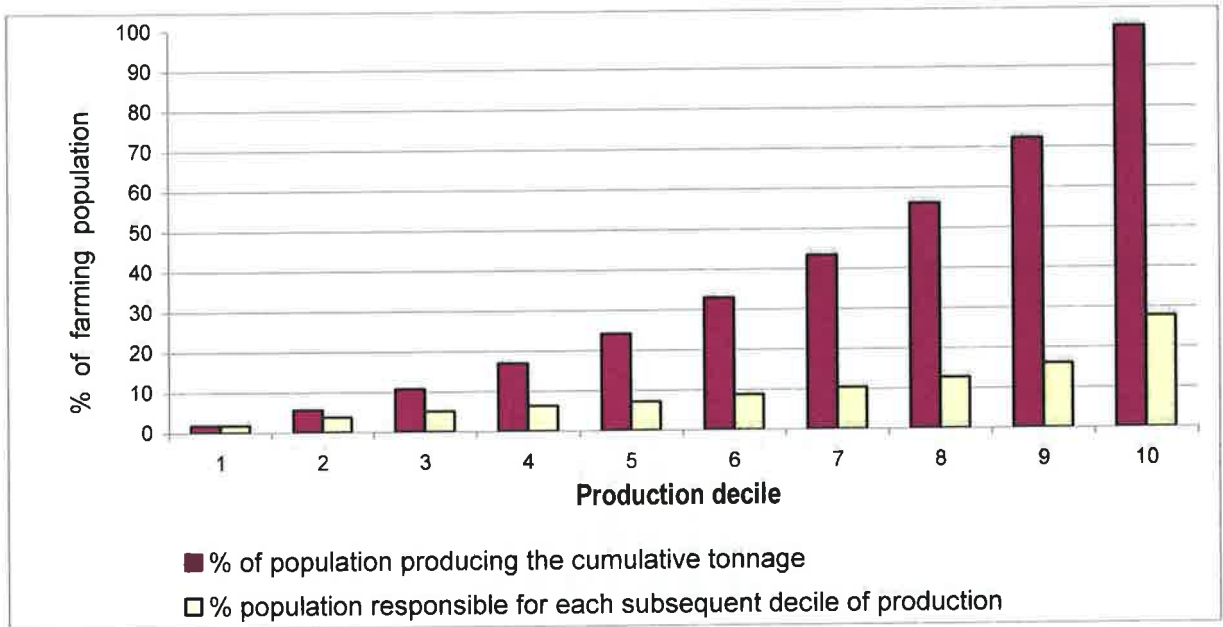
#### 4.2.5.2 Production output capabilities of respondents

Production capabilities associated with the target population (based on cumulative grain production outputs) are presented in Figure 4.27. Some 40% of the total grain production is produced by 17% of the farming population whilst 10% of total production is produced by just 1.8%. At the other end of the scale the final decile of production (10<sup>th</sup> decile) is produced by 27.8% of the survey population, indicative of the relative extremes in total grain production capacities across the survey population.

#### 4.2.5.3 Crop water-use efficiency

Crop water-use efficiency (in terms of wheat yield potential achieved) is represented on a Hundred basis in Figure 4.28. Results indicate that the highest yield potential levels were achieved in the northern Mallee, Northern and Yorke Peninsula districts (levels generally in excess of 65% yield potential). The lowest levels (less than 45% yield potential) were most noted on lower and western Eyre Peninsula.

**FIGURE 4.27: Wheat production (total tonnage 1997), representing number respondents responsible for each decile (in decreasing order of total on-farm production of wheat)**



**FIGURE 4.28: Percentage wheat yield potential achieved, represented on a Hundred basis**

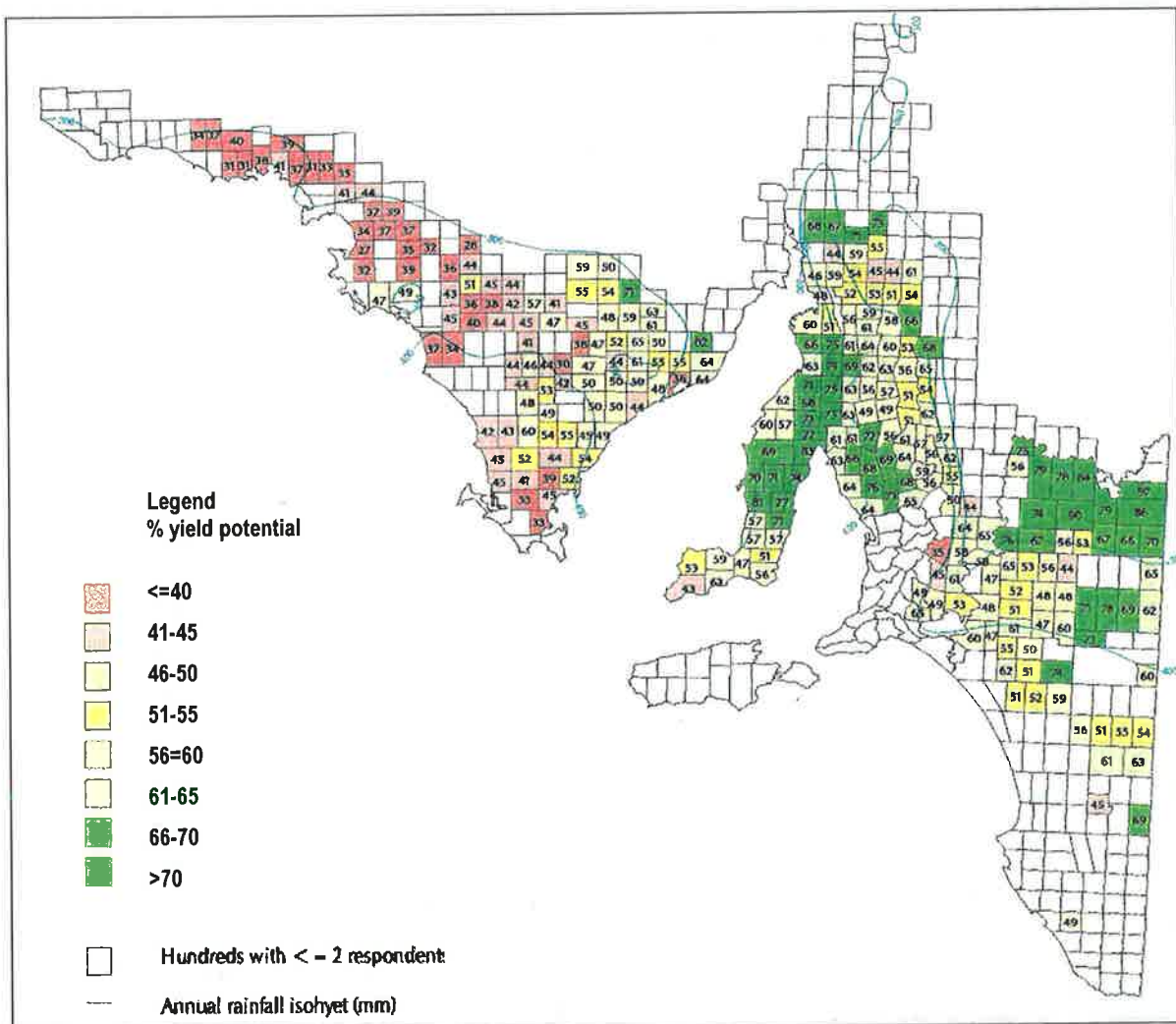
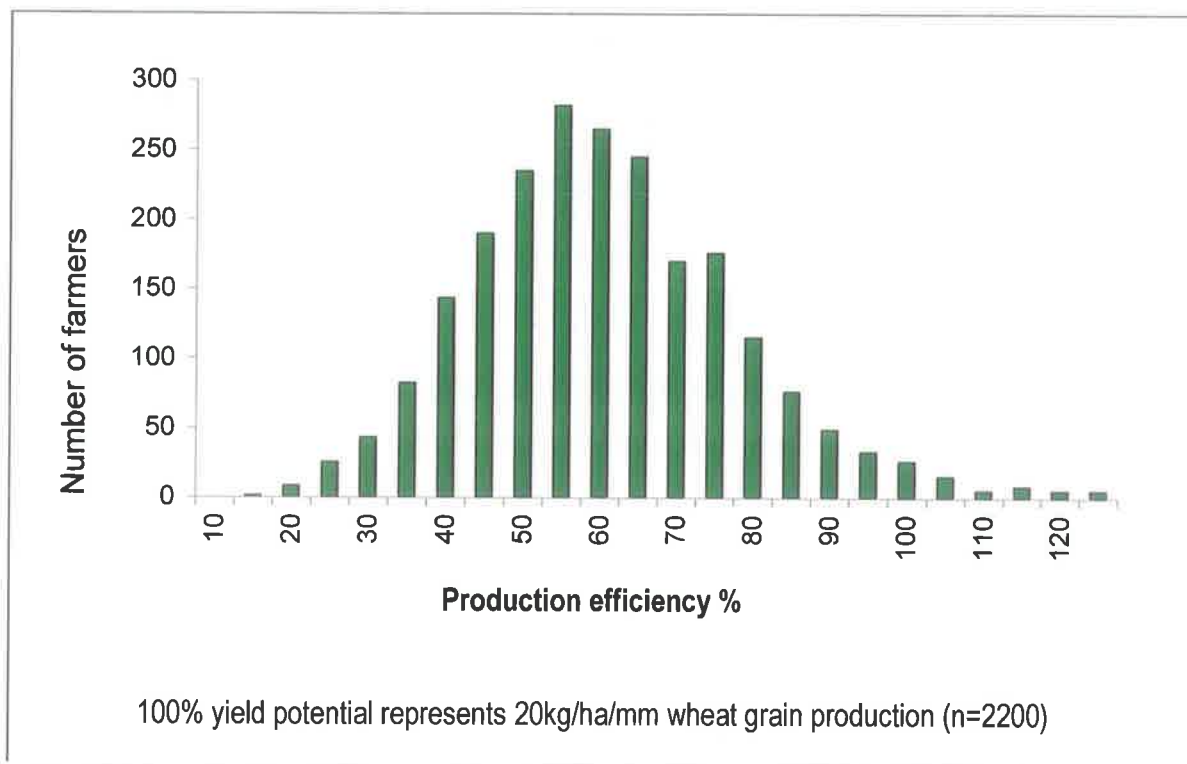


Figure 4.29 represents the distribution for water-use efficiency amongst respondents, with results generated from wheat crop yield data (based on current yields achieved at the time of the survey 1997). The distribution of yield potential data achieved amongst respondents provides a bell shaped curve. Data ranged from 20 to 140% water use efficiency, from 2200 respondents.

**FIGURE 4.29 Water-use efficiency distribution for wheat crops (1997 yield data)**



#### 4.2.6 Summary of situational characteristics

Over 95% of the respondents operate family owned farms, with the length of ownership for the majority of respondents between 31 and 40 years. Farm size on average was less than 1500 hectares with the largest farms located on western Eyre Peninsula and the northern Mallee. Total value of the family farm was in excess of \$500,000 with average farm business equity of 85%. Farmers across SA had achieved favourable yield increases over the past 10 years and were confident in their ability to increase yields over the next 5 years. Greatest yield increases were achieved in the higher rainfall districts of the State.

### **4.3 AGRICULTURAL KNOWLEDGE SYSTEMS CHARACTERISTICS**

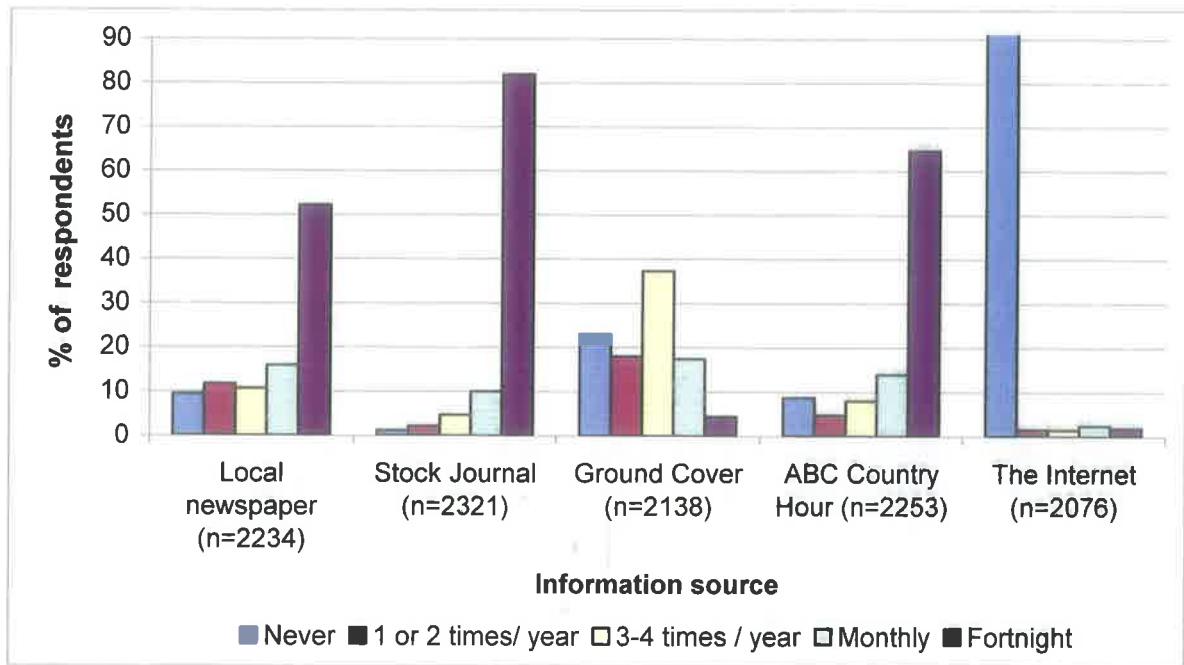
The purpose of this section is to provide an overview of the characteristics associated with the agricultural knowledge systems linked to this research study. Information presented relates to the nature of information sources (in terms of the nature, frequency and preferred sources of information) in addition to identifying the level of participation in group-based activities and information sources considered to be the most influential in relation to adoption decisions.

#### **4.3.1 Access and value of information sources and group participation**

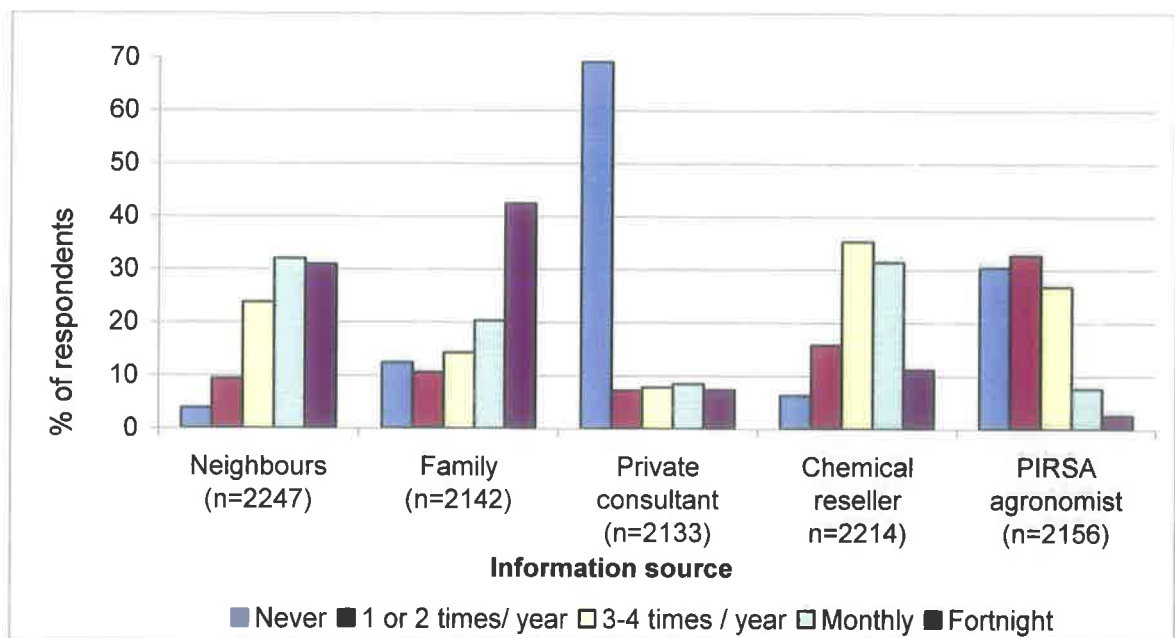
Survey respondents were asked to indicate from where they obtained information, and the value of the information source. This information assisted in providing an indication of the range, level and relative usefulness of information sources. Results for a range of printed and electronic information sources are presented in Figure 4.30. The ABC radio Country Hour program proved to be the most popular source, accessed by 91.3% of respondents, with the Internet being least popular, accessed by just 7.5% of respondents. In terms of printed information sources the weekly farmer newspaper the Stock Journal proved to be most popular, accessed by 98.8% of all respondents.

The level of access to a selected range of personal contacts is presented in Figure 4.31. Results indicated that most respondents (96.1%) gained information from their neighbours followed closely by their local chemical reseller (93.7%) and other family members (87.6%). Only 30.8% of respondents accessed information from private agricultural consultants. In terms of the frequency of access, neighbours were consulted the most frequently (62.9% using this source at least on a monthly basis) followed closely by family members (62.7%). Results capturing all information sources included in the survey are presented in Appendix L.

**FIGURE 4.30: Frequency of access to selected printed and electronic information sources**

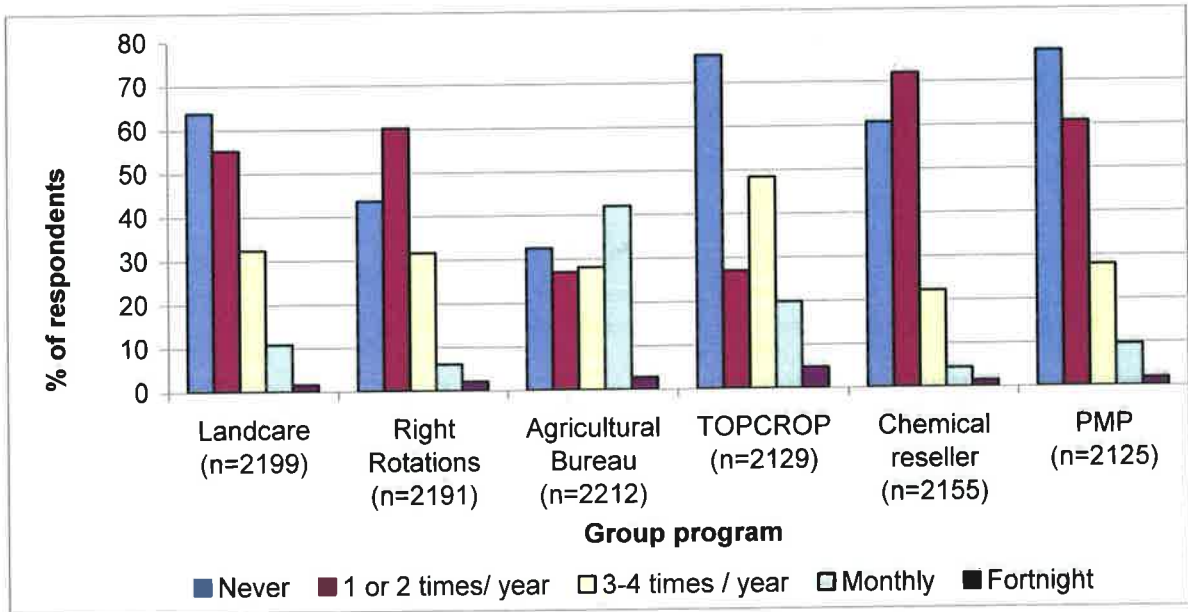


**FIGURE 4.31: Frequency of access to selected personal information sources**



The level of involvement of respondents in a range of group-based activities is summarised in Figure 4.32. The most common group based activity was found to be the Agricultural Bureau movement (participation by 67.5% of all respondents). Other groups having relatively high levels of participation were chemical reseller discussion groups (39.3% of all respondents), TopCrop (23.7%) and Property Management Planning (23.1%).

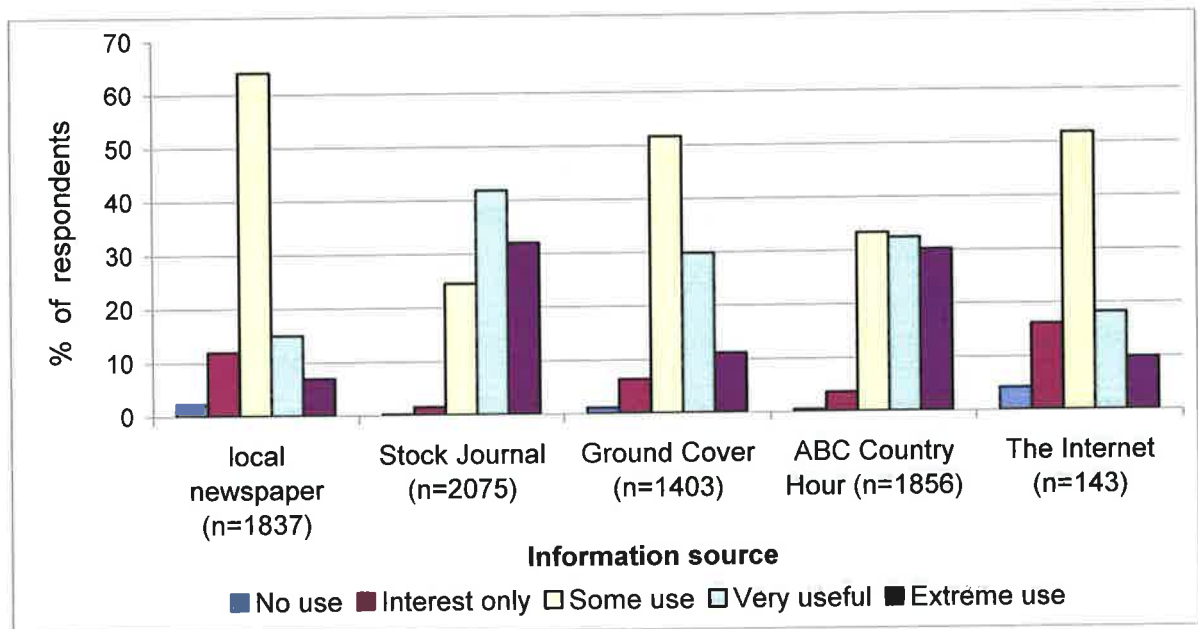
**FIGURE 4.32: Frequency of participation in selected group based training programs**



**4.3.2 Usefulness of information; printed, electronic, personal and group sources**

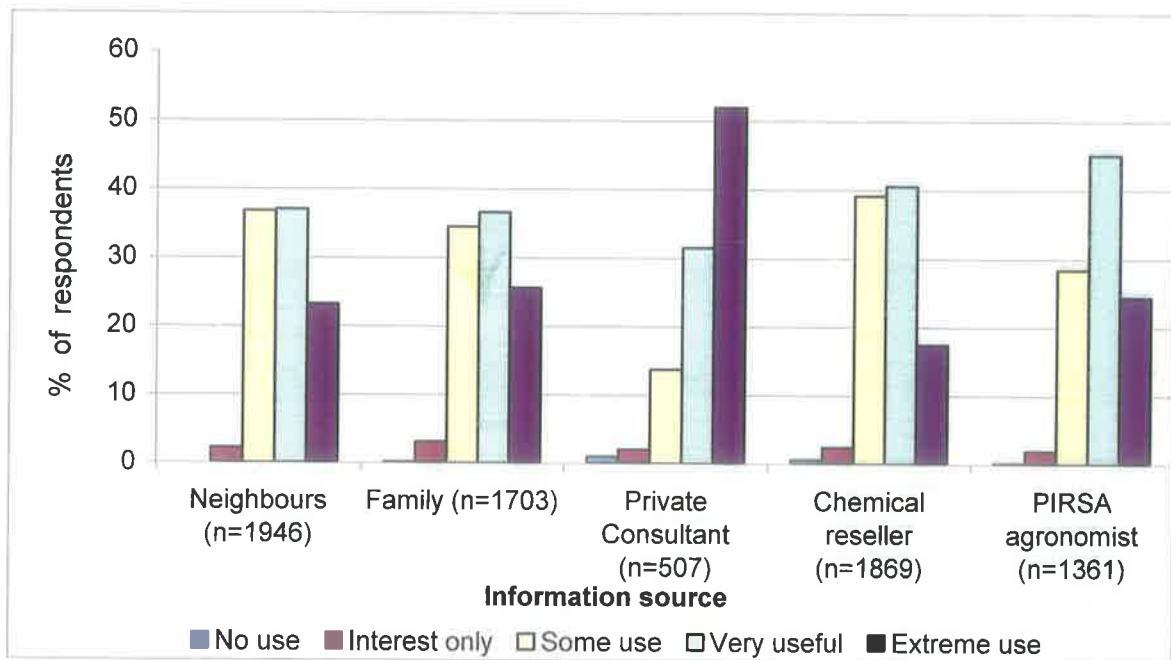
Results representing the perceived usefulness for a range of printed and electronic information sources are presented in Figure 4.33. The ABC Country Hour was rated the highest amongst the electronic media sources with 62.2% considering it to be very or extremely useful.

**FIGURE 4.33: Perceived value of information from a range of printed and electronic information sources.**



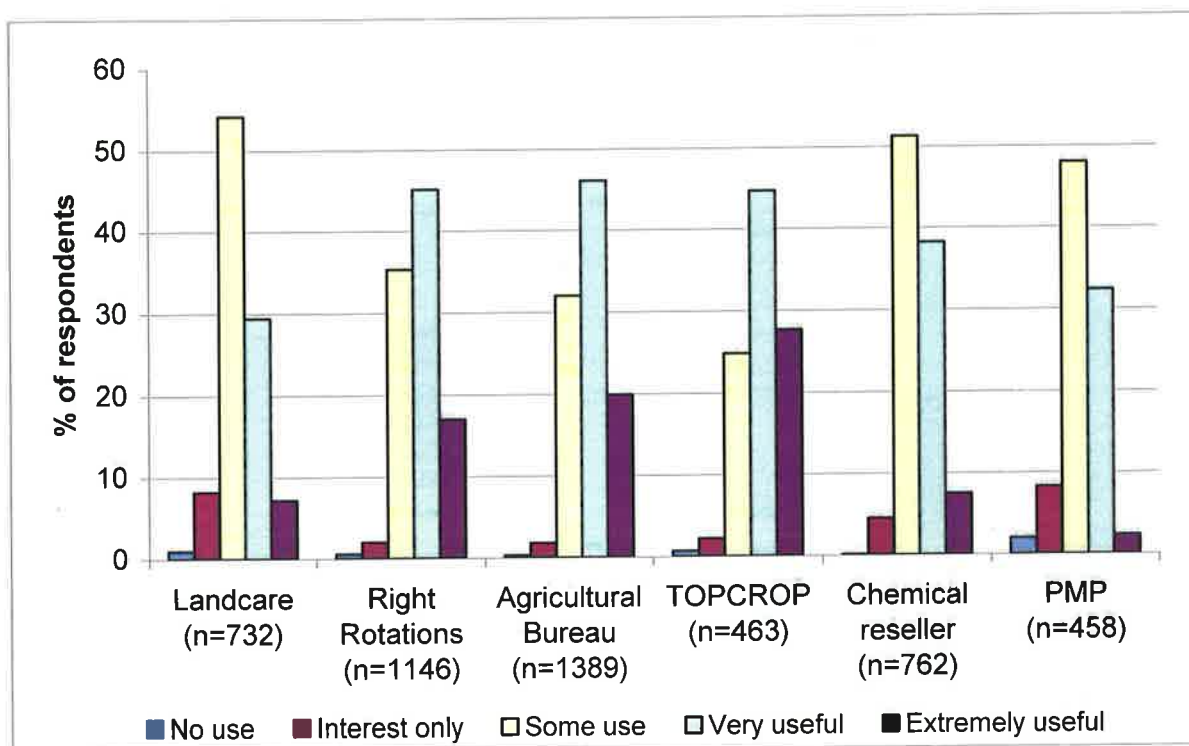
The perceived usefulness for a selected range of personal information sources is presented in Figure 4.34. Rated highest were private agricultural consultants, where 83.5% of respondents utilising this source provided a rating of either useful or extremely useful.

**FIGURE 4.34: Perceived value of information from a range of personal information sources**



Respondents rated the perceived value of participating in a range of selected group based training activities, with results presented in Figure 4.35. Rated highest were those involved in TopCrop groups (27.7% of respondents providing a rating of extremely useful) whilst at the other end of the scale only 2.3% of respondents considered being involved in Property Management Planning groups was an extremely useful exercise.

**FIGURE 4.35: Perceived value from participating in group based training programs**

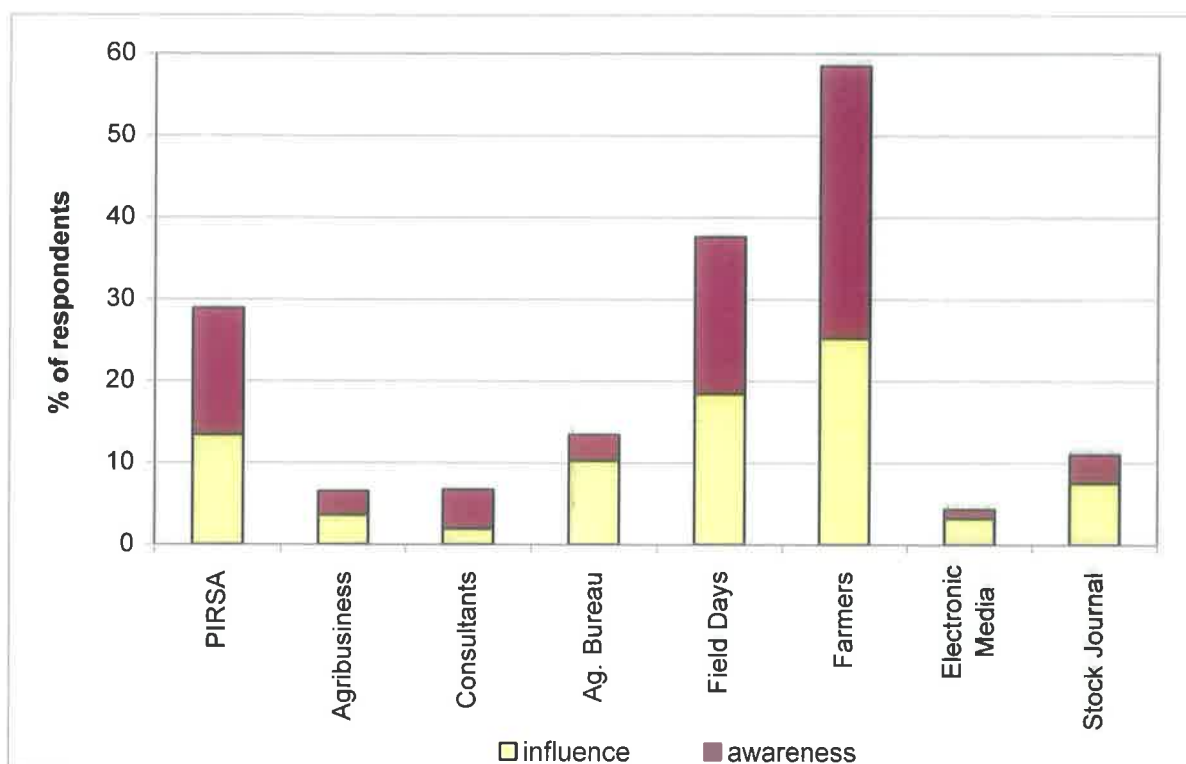


#### 4.3.3 Information sources and their role in creating awareness and influence

Survey respondents were asked to indicate from where they first heard about a number of different farming practices / innovations. They were then asked to respond to the question "Indicate the information source that you consider was the most influential in your decision to try and adopt the practice". Results for a number of selected practices are presented in Figures 4.36 to 4.39 (with an overview of all results provided in Appendix M).

Results for a range of practices are presented in the following text. The sources of information responsible for generating awareness of growing Frame wheat was dominated by other farmers (25.2% of respondents) and farmer field days and seminars (18.4%). In terms of respondents identifying the single most influential source for adoption, other farmers (33%) were the prime influential source leading to adoption. Results are summarised in Figure 4.36.

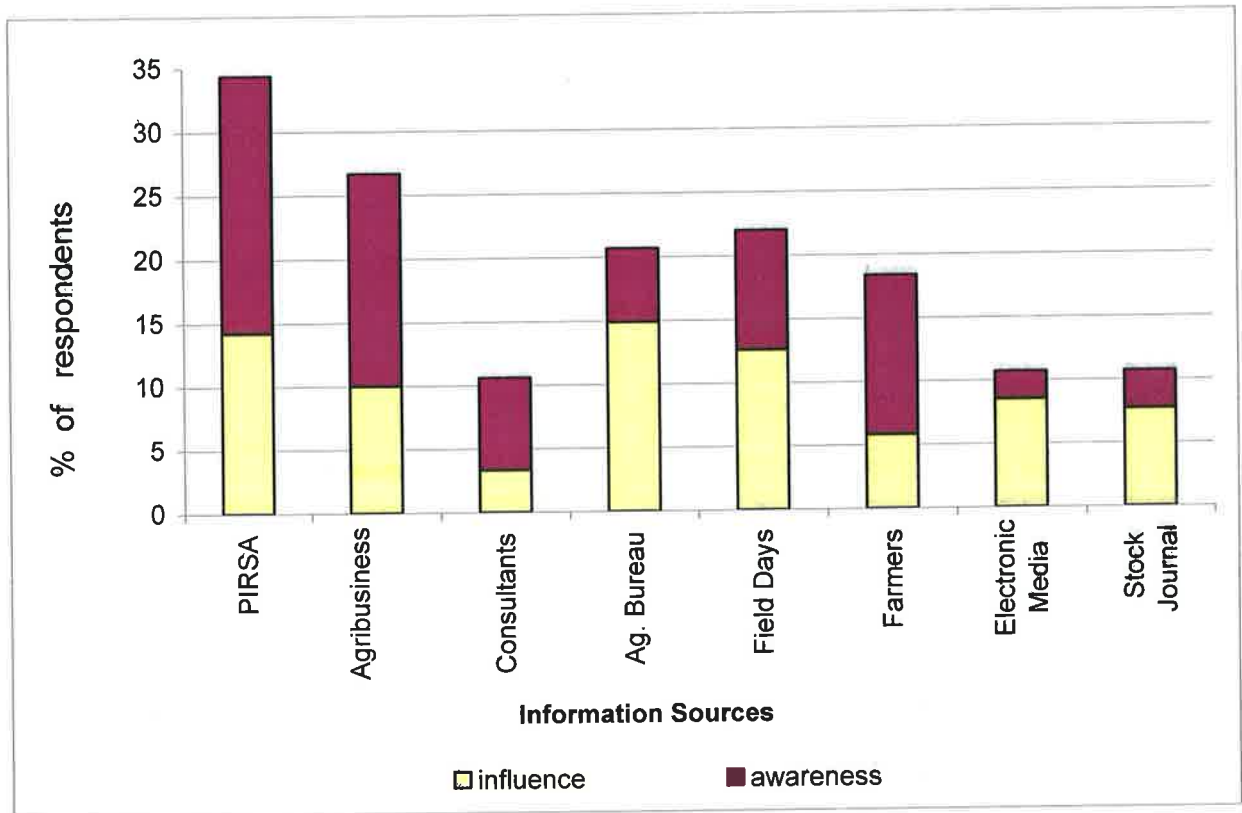
**FIGURE 4.36: The influence of information source in respect to creating awareness and influencing adoption of growing Frame wheat**



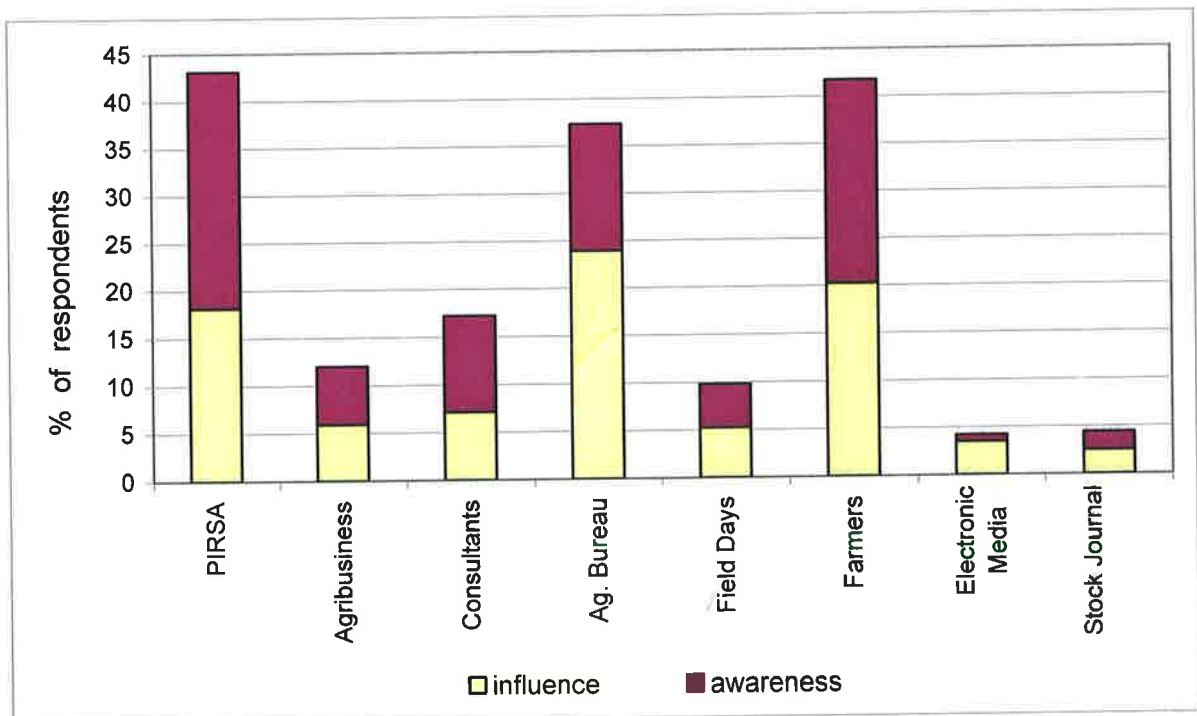
In relation to herbicide resistance management, the most important sources of information that created an awareness of this practice were the Agricultural Bureau (14.9%) and PIRSA agronomists (14.2%). PIRSA agronomists were considered the most influential source that led to adoption. Other influencing sources were agribusiness (16.7%) and other farmers (12.6%). Figure 4.37 provides an overview of the differences in relation to awareness and influence in respect to adopting the innovation. More often than not the source that created the initial awareness was not necessarily being the most influential in the farmer decision to adopt the technology.

The information sources that generated awareness in crop monitoring practices are presented in Figure 4.38. Information sources such as the Agricultural Bureau created the greatest awareness (23.9%), however the most influential sources that led to adoption were PIRSA agronomists (25%) and other farmers (21.5%).

**FIGURE 4.37: The influence of information source in respect to creating awareness and influencing adoption of herbicide resistance management**

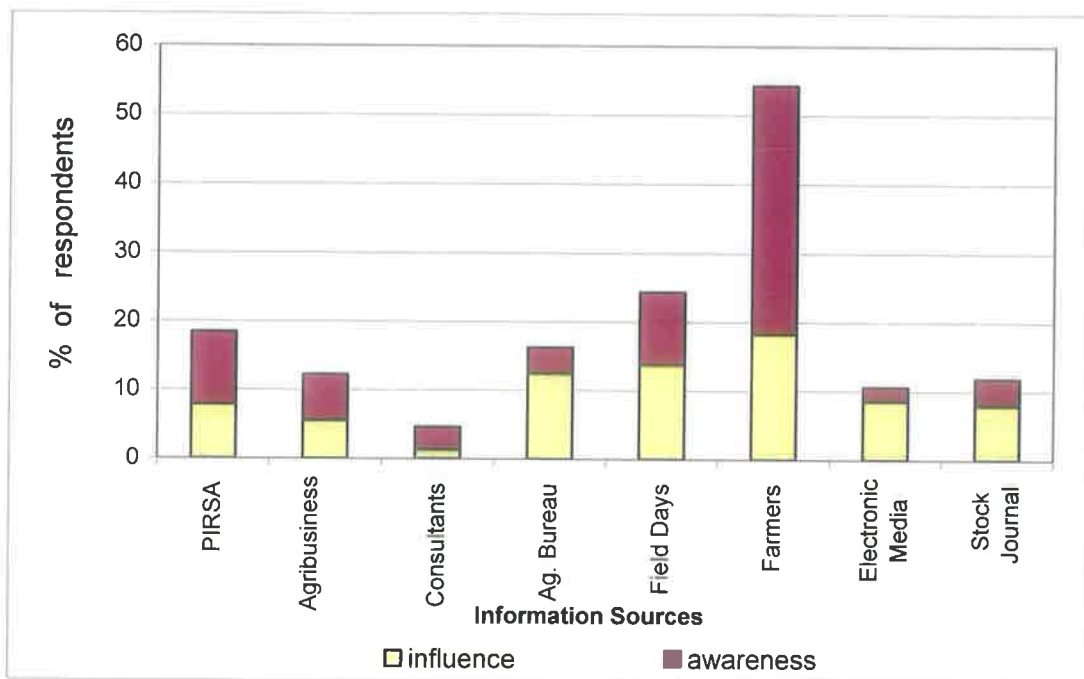


**FIGURE 4.38: The influence of information source in respect to creating awareness and influencing adoption of crop monitoring (n=1897)**



Awareness of minimum tillage was generated from information sources such as other farmers (18.2%), field days and seminars (13.7%) and the Agricultural Bureau (12.4%). The single most dominating influence that led to adoption were other farmers, with 36 % of respondents citing this as the single most important source. Results are illustrated in Figure 4.39.

**FIGURE 4.39: The influence of information source in respect to creating awareness and influencing adoption of minimum tillage**



#### 4.3.4 Summary of agricultural knowledge systems characteristics

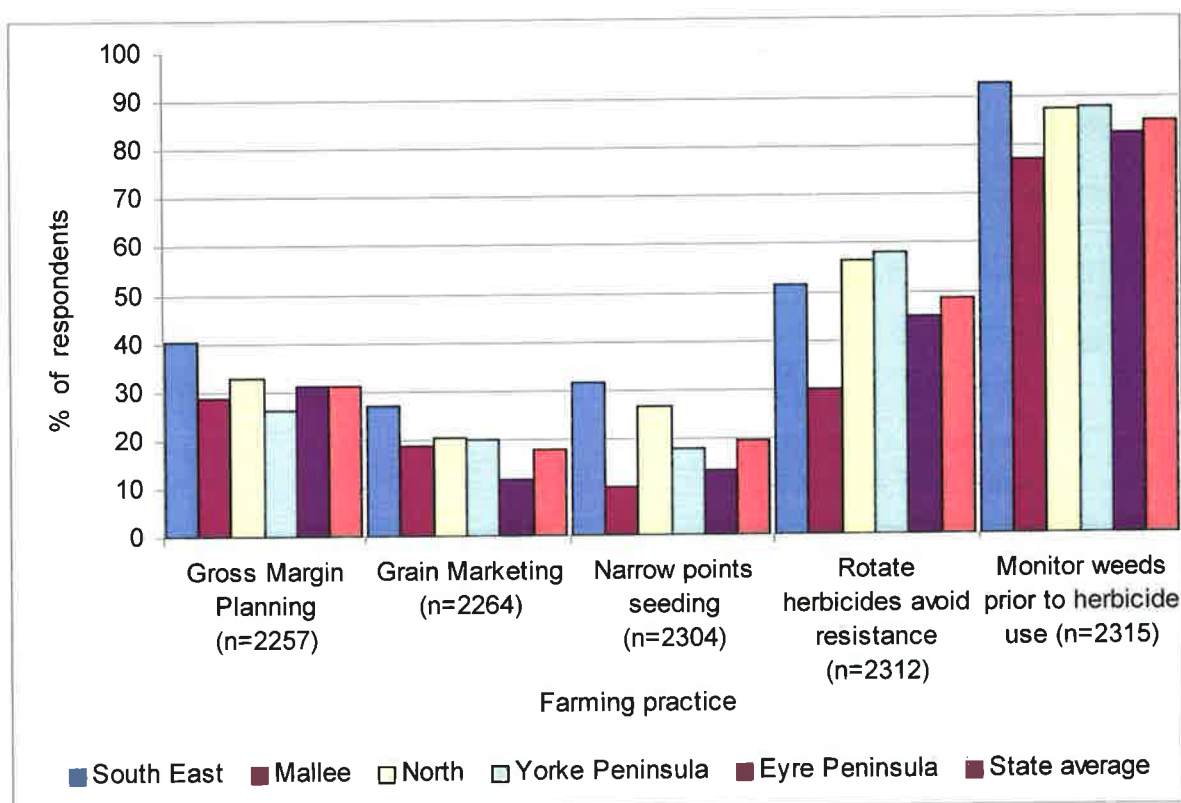
Most respondents tended to access information relating to cropping management practices from information sources that were considered readily acceptable. These include sources such as the Stock Journal and the Country Hour, with personal sources including neighbours, family members and the local chemical reseller. Respondents were more likely to be members of a local Agricultural Bureau, have been involved in a Right Rotations (cropping technology) workshop and usually attended machinery, stubble handling and Agricultural Bureau field days.

## 4.4 THE ADOPTION PROCESS – CHARACTERISTICS OF THE TARGET POPULATION

### 4.4.1 Adoption of best management practices

The rates of adoption for different practices are presented in Figure 4.40, with full results presented in Appendix S. The monitoring of weeds on-farm was adopted by 85.2% of the survey population (with values ranging from 77.3% on Eyre Peninsula to 92.8% in the South East). Other practices such as use of narrow points on seeding equipment were adopted by fewer numbers (19.3% in total, with values ranging from 10.1% on Eyre Peninsula to 31.7% in the South East). In some instances there were marked differences in the adoption of practices between regions (for example, the practice of rotating herbicide groups ranged from 29.9% in the Mallee to 57.9% on Yorke Peninsula).

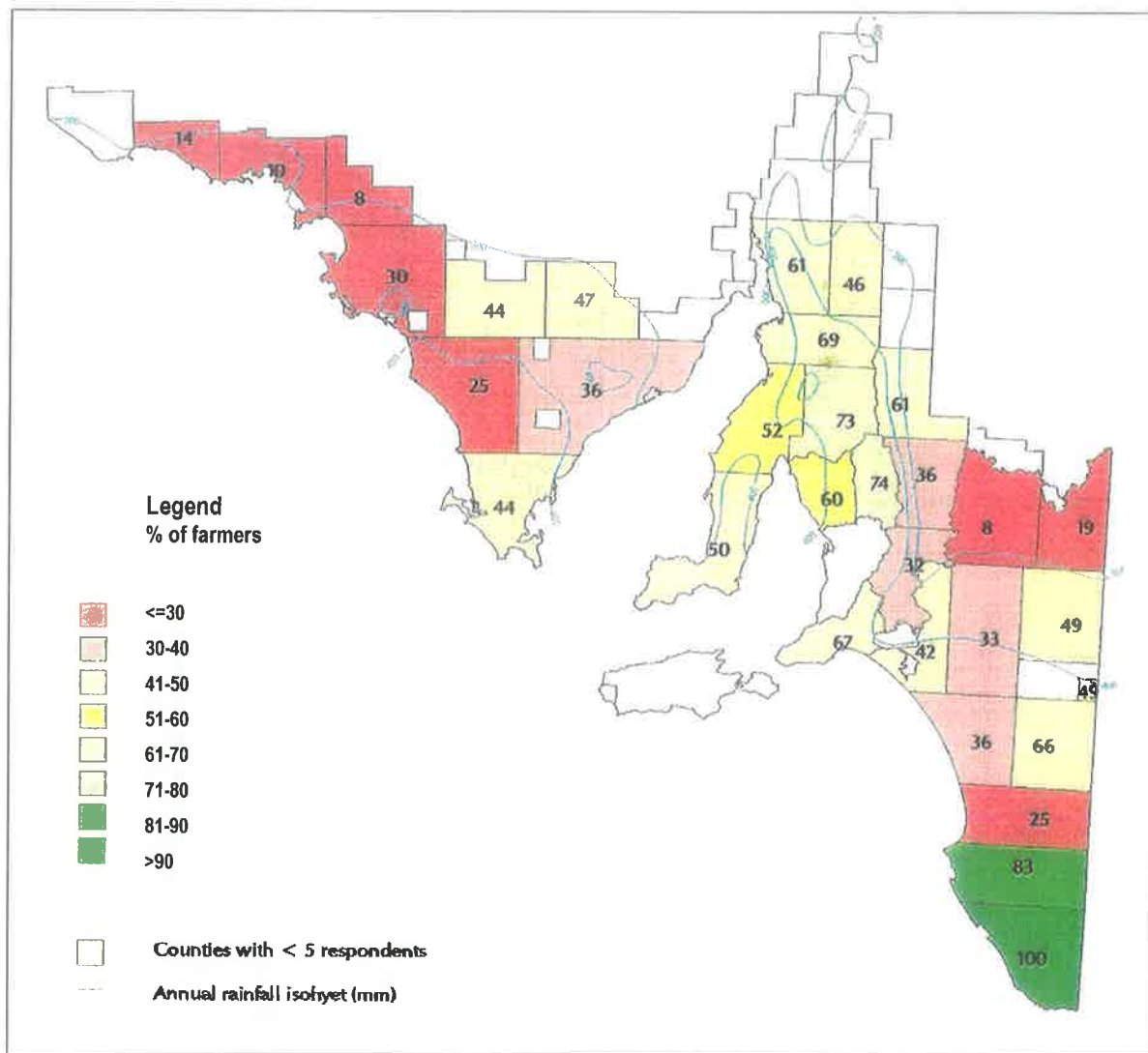
**FIGURE 4.40: Adoption of a selected number of best management practices**



Data relating to adoption rates for a number of farming practices were then represented on a County basis, and are presented in the following text. Figure 4.41 provides an overview of the adoption of

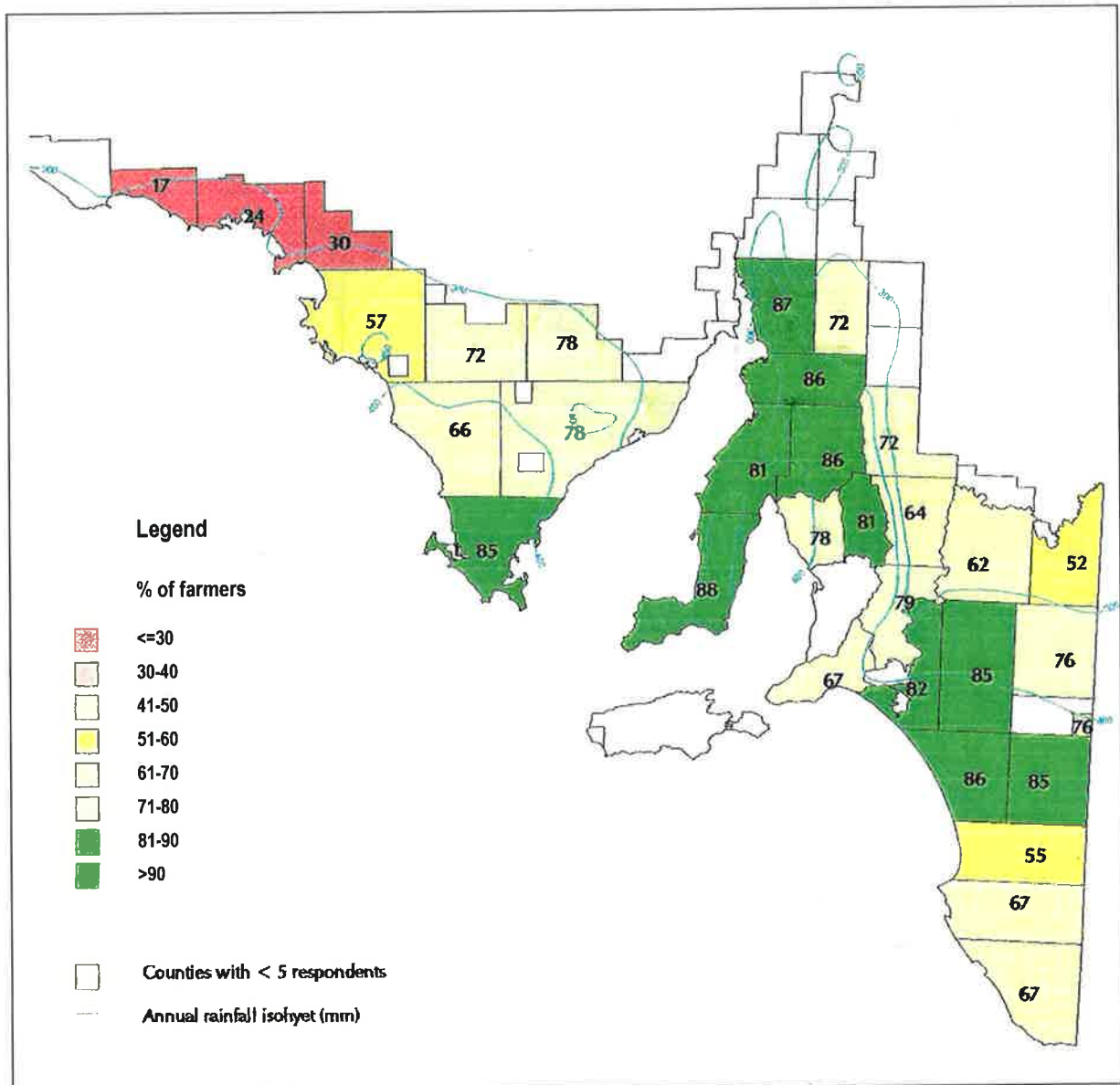
narrow points on seeding equipment. Rates of adoption vary considerably across SA, with rates highest in the higher rainfall districts of the South East, Northern and Yorke Peninsula.

**Figure 4.41: Adoption of narrow points amongst survey respondents (represented on a County basis)**



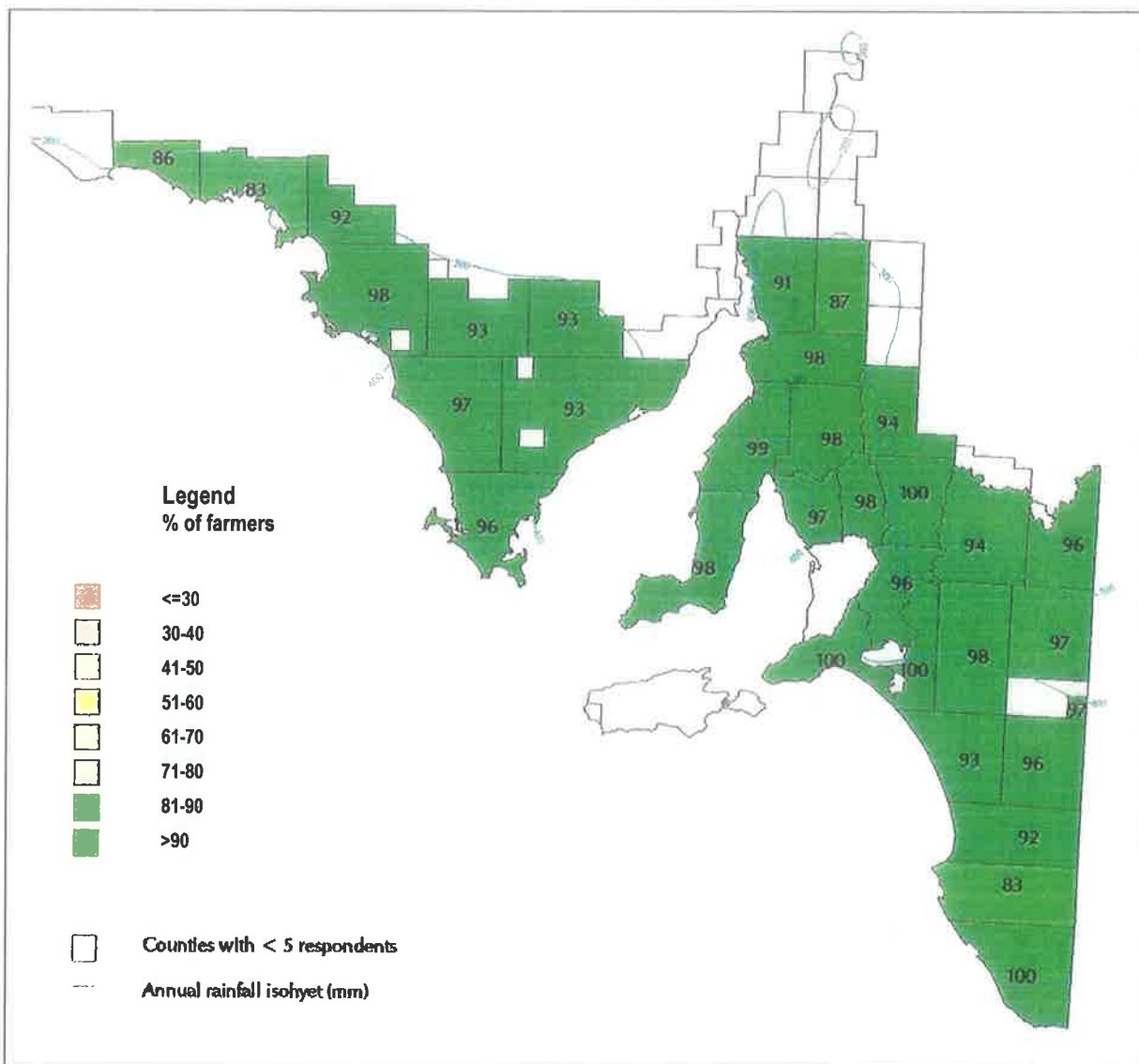
The adoption rates associated with the application of fungicidal seed dressings on barley are represented on a County basis in figure 4.42. Results indicate that adoption rates vary across the State, with lower levels of adoption in lower rainfall districts.

**FIGURE 4.42: Use of fungicidal seed dressings on barely crops (represented on a County basis)**



As a contrast, Figure 4.43 provides a geographical representation of the adoption of disease resistant cereal varieties (linked to crop rotation planning) undertaken by farmers. In this instance adoption rates have been extremely high (and uniform) across all Counties.

**FIGURE 4.43: Adoption of disease resistant cereal varieties (represented on a County basis)**



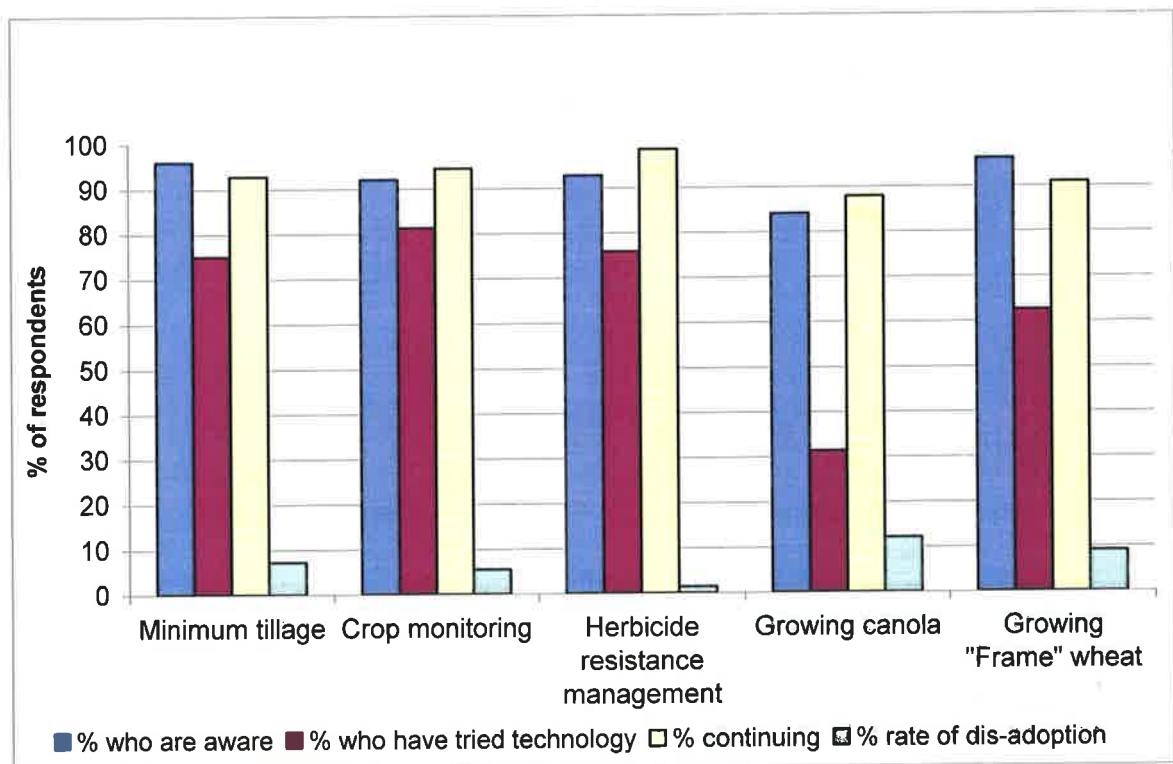
#### 4.4.2 Adoption characteristics

Information was sought in relation to the adoption characteristics associated with a range of farming practices. Responses were sought from a series of question prompts presented as a decision tree flow chart (refer to the survey questionnaire presented in Appendix A). Questions related to the identification of information sources that were considered to create an awareness of, and influence in adoption of the practice, perceived benefits and barriers to adoption and the reasons for dis-adoption of the practice. A summary relating to the level of awareness, adoption and dis-adoption relating to a

number of selected technology examples are presented in Figure 4.44 with more comprehensive results for all examples provided in Appendix O.

The results indicate that farmers held a relatively high level of awareness relating to the different practice examples presented. There was a greater variability in the percentage of farmers who had actually tried the range of practices, with adoption rates ranging from 31.3% of farmers having adopted canola production to 81.3% of farmers who had adopted crop-monitoring systems. Information was collected in relation to the percentage of farmers who had continued to adopt the particular technology. Continued adoption rates for the different practices ranged from 87.9% for canola through to 98.6% for herbicide resistance.

**FIGURE 4.44: Awareness and adoption of a selected number of innovations**

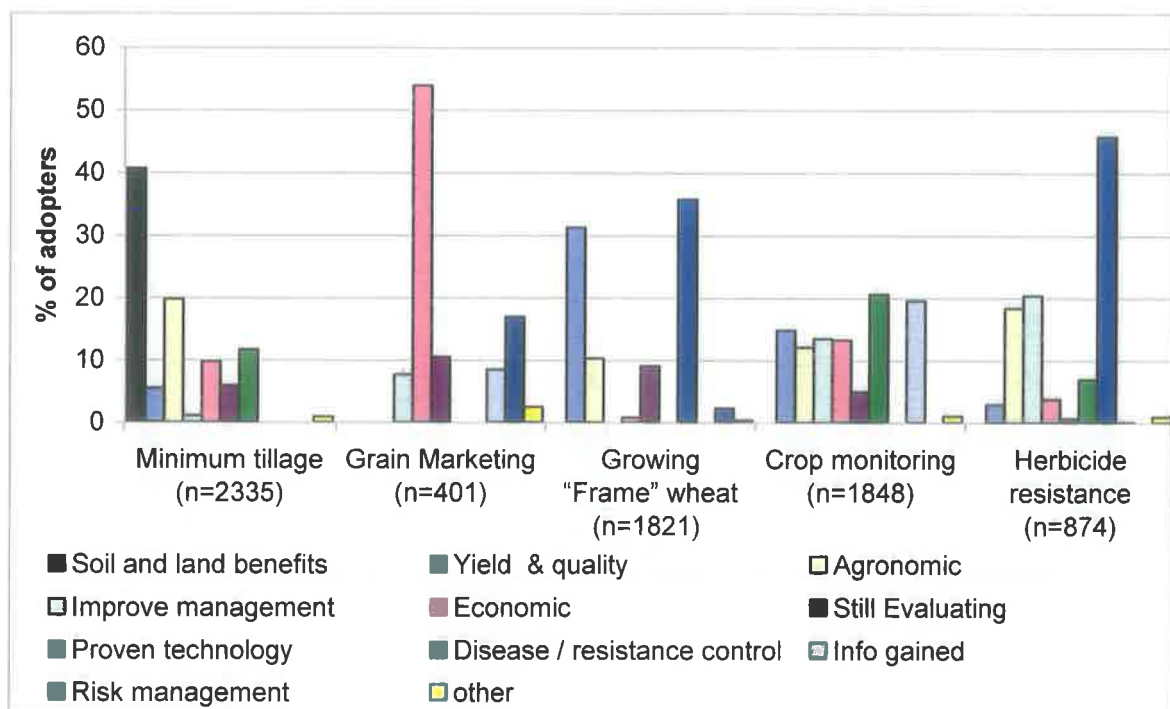


#### 4.4.3 Reasons for continued adoption

Respondents who had adopted particular practices were asked to indicate the reasons for their continued adoption. Results for selected practices are presented in Figure 4.45 (with data for all

practices provided in Appendix P). Reasons for the continued adoption of minimum tillage was dominated by the benefits provided to soil and land management (40.7% of respondents) with other benefits including improved agronomic management and proven technology (19.8% and 11.7% respectively). Economic benefits was cited by 53.9% of respondents for the continued adoption of grain marketing plans followed by improved risk management for 17% of respondents. The reasons indicated for continuing the growing of Frame wheat were yield/quality and disease control (31.3% and 35.8% of respondents respectively). Those respondents continuing with crop monitoring cited proven technology (20.6%), information gained (19.6%) and yield/quality benefits (14.8%) as the main reasons. Maintaining the adoption of herbicide resistance programs was influenced by benefits such as ongoing resistance control (45.8%), improved management (20.4%) and agronomic considerations (18.4%).

**Figure 4.45: Reasons for continued adoption of practices by adopters**

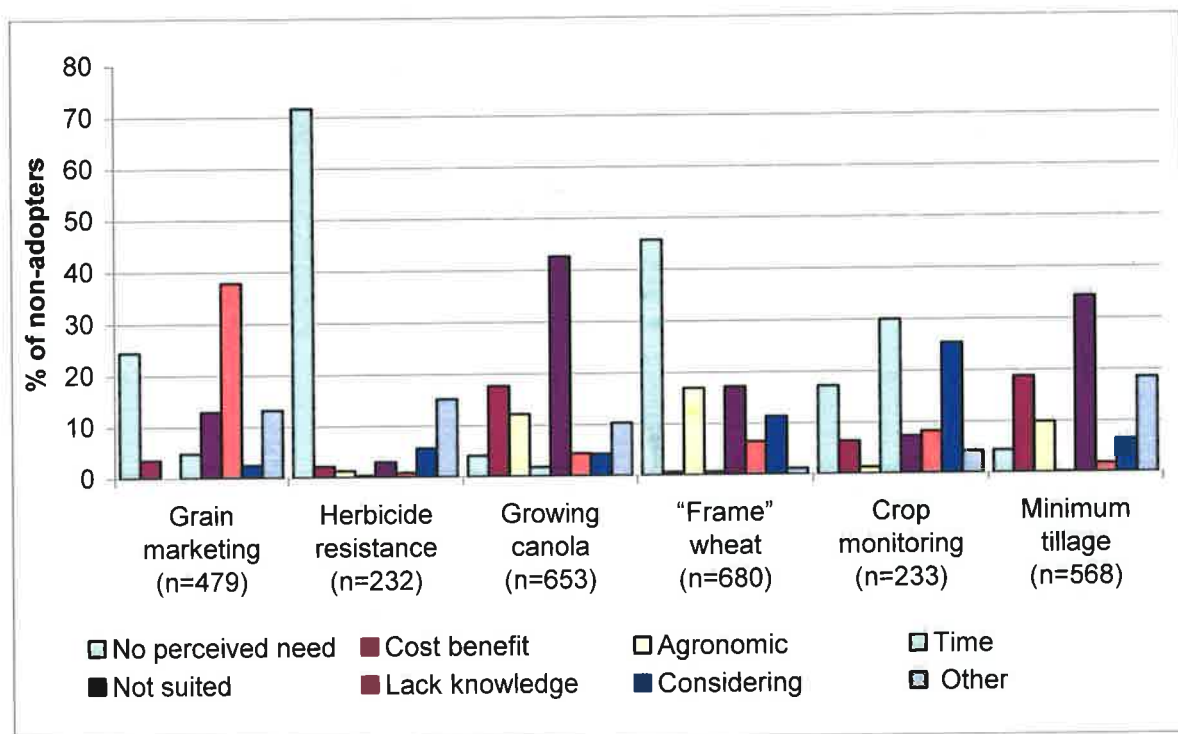


#### 4.4.4 Reasons for non-adoption

Respondents indicated reasons for non-adoption, with selected results presented in Figure 4.46 (and all practices presented in Appendix Q). Common to many is the reason of no perceived need, as

demonstrated with Frame wheat (45.7%) and herbicide resistance management (71.6%). The perception of the practice not being suited to a farming environment was a common response for the non-adopters of minimum tillage (34.3%) and growing canola (42.6%). A lack of knowledge in grain marketing was cited by 37.8%, and a lack of available time by 30% of crop monitoring non-adopters.

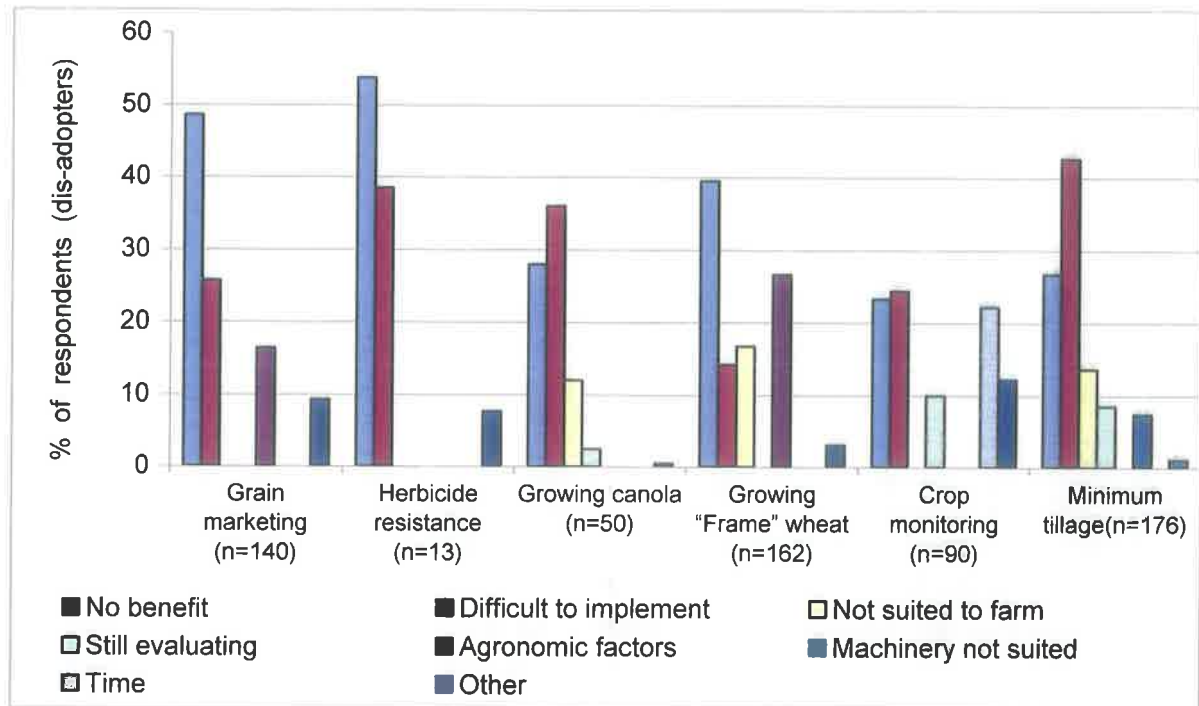
**FIGURE 4.46: Reasons for non-adoption of a selected number of practices**



#### 4.4.5 Reasons for dis-adoption

Respondents who had initially adopted the practice but then dis-adopted were asked to indicate reasons for dis-adoption. Results for a selected number of practices are presented in Figure 4.47, with all results presented in Appendix R. The most common response for dis-adoption related to the perception of the practices offering no benefit, such as Frame wheat (39.5%), grain marketing (48.6%) and herbicide resistance (53.8%). Another common reason for dis-adoption included the perception of the difficulty in implementing the practice, such as the case of growing canola (36%), herbicide resistance management (38.5%) and minimum tillage (42.6%). Some respondents whilst they had dis-adopted the practice were still evaluating the suitability of the practice (8.5% minimum tillage and 10% crop monitoring dis-adopters).

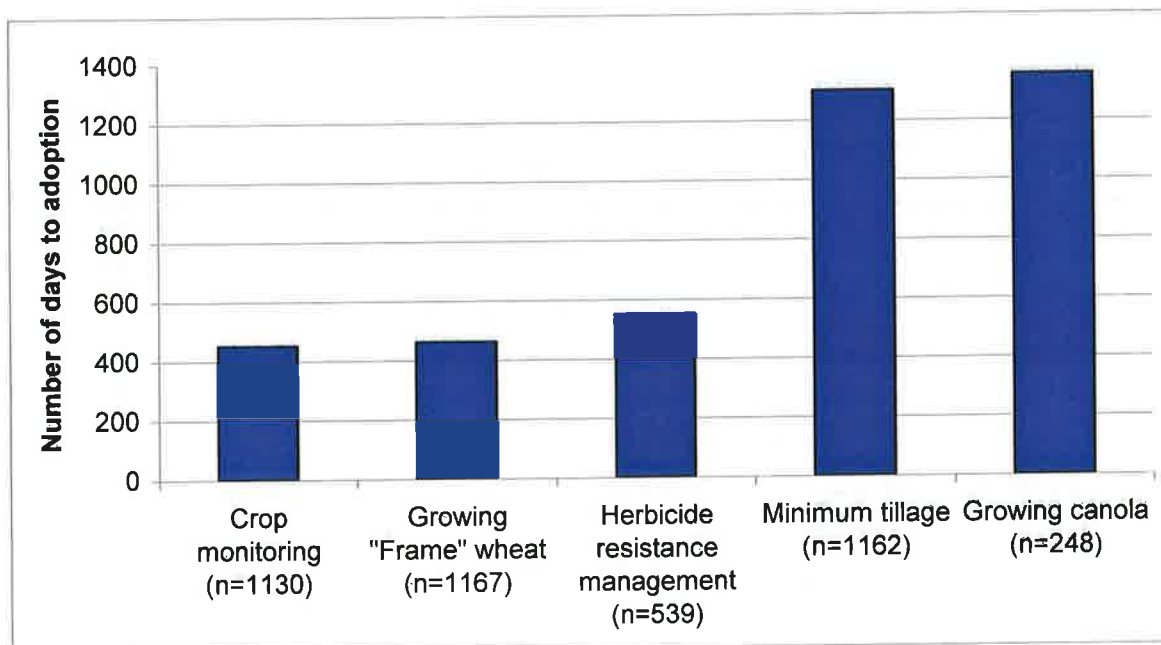
**FIGURE 4.47: Reasons cited by dis-adopters of particular practices**



#### 4.4.6 Time lag to adoption

Respondents were asked to indicate when they had first become aware of a particular technology, and when they had adopted it. From this, an approximation of the number of days that it had taken to adopt the specific practice was then calculated. Results for different examples are presented in Figure 4.48. It is evident that some technologies were more rapidly adopted than others. Examples of relatively rapid adoption include crop monitoring (452 days), growing Frame wheat (462 days) and herbicide resistance management (551 days). Technologies such as minimum tillage and growing canola took significantly longer to adopt (1302 and 1354 days respectively). The differences in rates of adoption may be due to the relative complexities of the particular technology (related to ease of adoption), the specific risks and implications on overall farm management and cost. The monitoring of crops and changing a particular wheat variety may be considered relatively simple and cheap technologies to introduce, whilst introducing technologies such as minimum tillage and canola production involve higher degrees of complexity, cost and risk.

**FIGURE 4.48: Time lag to adoption for a selected number of technologies**



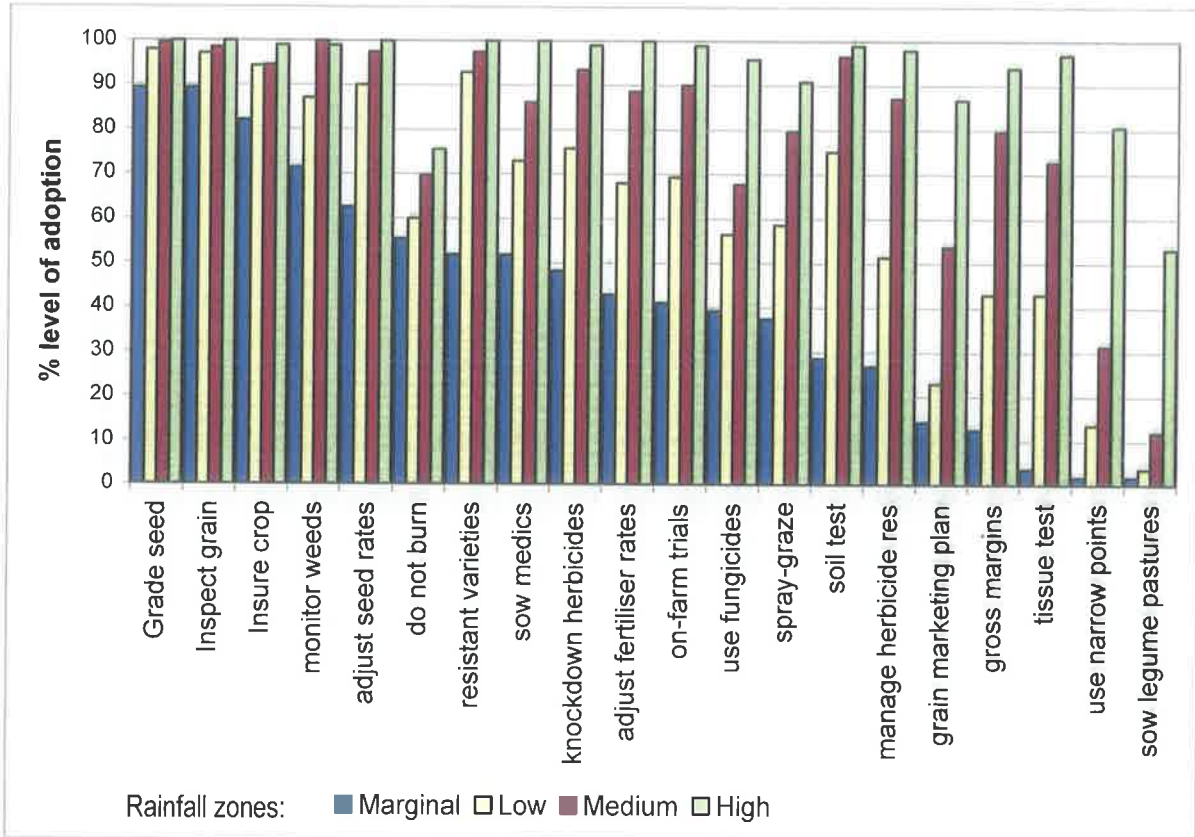
#### **4.4.7 Adoption rates for best management practices**

In order to identify if adoption rates are influenced by the farming environment (average growing season rainfall) adoption rates for a range of best management practices were presented on the basis of rainfall categories (marginal, low, medium and high rainfall zones). Results (presented in Figure 4.49) indicate the following observations:

- In marginal districts no practices exceed an adoption level of 90%
- In the high rainfall districts all practices achieved a rate of adoption in excess of 50%.
- As rainfall increases so does the relative rate of adoption of the practices.

Some practices achieved relatively moderate to high levels of adoption across all three-rainfall zones, and included grading seed, inspecting grain for pests, and insuring the crop. Practices that achieved high adoption levels in high rainfall districts and extremely low adoption rates in marginal rainfall districts included use of narrow points, use of business management tools (gross margin planning and grain marketing plans), plant tissue testing, and sowing of pasture legumes.

Figure 4.49: Adoption rates for a range of best practices across different rainfall zones.



#### 4.4.8 Summary of adoption characteristics

In terms of the adoption of practices, most respondents generally grade and pickle their seed, insure the crop for fire and hail, sow disease resistant crop varieties, check the crop for weeds before spraying, and undertake grain hygiene on-farm. Most are aware of some of the more recently developed farming technologies, but as yet have not adopted them. These include yield mapping, grain marketing and risk management, and growing new crops such as canola. There is variability in the level of adoption across different regions of SA, in addition to adoption rates across rainfall zones observed.

## **4.5 DIFFERENTIAL ATTRIBUTES OF THE SURVEY POPULATION & ASSOCIATED VARIABLES**

### **4.5.1 Tests of association – identifying relationships between variables**

Tests of association were conducted for selected variables using Pearson's correlation co-efficient analysis, which helped to assist in the interpretation of adoptive behaviour amongst the target population. The following provides a summary of a number of key relationships between variables (where measurements of association were statistically significant).

### **4.5.2 Personal and situational characteristics**

Length of farm ownership was positively associated with equity levels ( $r = 0.27$ ,  $p < 0.0001$ ). Number of years involved in farming was inversely associated with level of education ( $r = -0.38$ ,  $p < 0.001$ ). Rainfall was positively associated with yield (wheat) ( $r = 0.68$ ,  $p < 0.0001$ ), and inversely related to grain protein ( $r = -0.44$ ,  $p < 0.0001$ ). Crop area sown was positively associated with machinery value ( $r = 0.39$ ,  $p < 0.001$ ).

### **4.5.3 Best practice relationships**

Cultivation of dry soils was positively associated with areas sown to oats ( $r = 0.31$ ,  $p < 0.001$ ) and negatively associated with rainfall ( $r = -0.25$ ,  $p < 0.001$ ). The sowing of oats is a common practice across many parts of Eyre Peninsula, often sown into dry soil prior to the break of the season.

Burning stubbles was positively associated with rainfall ( $r = 0.28$ ,  $p < 0.0001$ ) and wheat yield ( $r = 0.26$ ,  $p < 0.001$ ). This is likely to be associated with higher biomass produced, and/or incidence of European snails (more prevalent in higher rainfall environments, and controlled through burning of plant residues).

Long fallow was positively associated with cultivation of dry soils ( $r = 0.24$ ,  $p < 0.0001$ ), area sown to rye ( $r = 0.29$ ,  $p < 0.0001$ ), with negative relationships to rainfall ( $r = -0.33$ ,  $p < 0.0001$ ) and wheat yield ( $r = -0.23$ ,  $p < 0.0001$ ). Fallowing is more common in the lower rainfall districts of the Mallee and Upper North. These areas are characterised by higher incidences of dry soil cultivation and lower wheat yields, whilst the sowing of rye is common to the Mallee region.

Narrow points was positively associated with the number of information sources ( $r = 0.31$ ,  $p < 0.0001$ ), wheat yield ( $r = 0.32$ ,  $p < 0.001$ ), adoption of multiple innovations ( $r = 0.40$ ,  $p < 0.0001$ ), direct drilling ( $r = 0.38$ ,  $p < 0.0001$ ), use of knockdown herbicides ( $r = 0.32$ ,  $p < 0.0001$ ), soil tests for fertility ( $r = 0.27$ ,  $p < 0.0001$ ) and innovativeness ( $r = 0.37$ ,  $p < 0.0001$ ). From this, it is evident that those who have adopted the use of narrow points actively seek out information, and are innovative. Relationships with the adoption of other practices indicate that adoption of practices takes place in an integrated manner, as opposed to adopting practices in isolation to one another. This is also supported by those adopting a number of other farming practices. The adoption of red-legged earth mite control was positively associated with wheat yield ( $r = 0.49$ ,  $p < 0.0001$ ) and rainfall ( $r = 0.40$ ,  $p < 0.001$ ). Grass herbicide use was positively associated with red-legged earth mite control ( $r = 0.29$ ,  $p < 0.0001$ ), sow medic pastures ( $r = 0.29$ ,  $p < 0.0001$ ), spray grazes pastures ( $r = 0.28$ ,  $p < 0.0001$ ), spray top pastures ( $r = 0.27$ ,  $p < 0.0001$ ) and rotate herbicide groups ( $r = 0.23$ ,  $p < 0.0001$ ).

On-farm trials were positively associated with information sources ( $r = 0.31$ ,  $p < 0.0001$ ), innovations adopted ( $r = 0.29$ ,  $p < 0.0001$ ), gross margins ( $r = 0.29$ ,  $p < 0.0001$ ) and tissue test ( $r = 0.25$ ,  $p < 0.0001$ ). This suggests that farmers undertaking on-farm trials utilised a range of information sources and information seeking behaviours, leading to a higher rates of adoption of a range of farming practices.

Results have identified logical patterns of adoption between practices that suggests adoption occurs in an integrated manner between complimentary farm practices. Farmers who used a greater number of information sources were likely to adopt a greater number of farming practices, including no-till crop establishment systems. Farmers who were described as being innovative had tried a greater number of innovations and produced higher wheat yields.

#### **4.5.4 Conservative and traditional farmers**

Respondents describing themselves as conservative and traditional were found to have a positive relationship with the attitudinal statement "would not try a new chemical until it was well proven" ( $r = 0.49$ ,  $p < 0.0001$ ), whilst having negative relationships with outlook on farming ( $r = -0.68$ ,  $p < 0.0001$ ), the number of innovations tried ( $r = -0.46$ ,  $p < 0.0001$ ), the number of information sources accessed ( $r = -0.32$ ,  $p < 0.0001$ ), level of education achieved ( $r = -0.29$ ,  $p < 0.0001$ ) and group involvement ( $r = -0.26$ ,  $p < 0.0001$ ). This is indicative of the conservative approach to farming held by these respondents, and the low adoption levels for many farming practices. Conservative farmers had low levels of education, low number of information sources and group participation, and a negative outlook on farming.

#### **4.5.5 Information access**

Positive relationships were identified between frequency of group participation and the number of innovations tried ( $r = 0.41$ ,  $p < 0.0001$ ) and outlook on farming ( $r = 0.33$ ,  $p < 0.0001$ ). It is evident that respondents with higher levels of group involvement were more likely to try new innovations, and held a positive outlook on farming. This process helped identify sets of variables for inclusion in the PCA.

### **4.6 COMPARISON OF VARIABLES ACROSS SURVEY POPULATION SEGMENTS**

Characteristics of the population were compared through segmenting the population based on a number of set criteria. This was carried out in order to determine if to what degree specific personal and

situational variables were linked to adoption, productivity and conservatism. The analysis did not attempt to explain differences in the population or the degree of inter-relationships between variables.

In all examples the top 25% (quartile) of the population were compared with the bottom 25% (quartile). Comparisons were made on the basis of adoption, production capability (derived from wheat yield potential) and farmer innovativeness. Mean values with significant differences between the top and bottom quartiles for each of the three sets of comparisons are presented in Table 4.1.

**TABLE 4.1: Comparison between top and bottom quartile values for three separate analyses, involving adoption of innovations, production capability and farmer innovativeness (in comparison to a range of personal and situational factors associated with the target population).**

Variable	Adoption of innovations		Production capability (potential wheat yield)		Innovativeness	
	Bottom 25%	Top 25%	Bottom 25%	Top 25%	Bottom 25%	Top 25%
<b>Personal characteristics</b>						
Age score	4.2	4.0***	4.2	4.0**	4.4	3.9***
Experience - years involved in farming	30.8	28.7***	30.3	29.3ns	33.5	27.2***
Innovativeness score	-1.8	1.1***	-1.3	0.6***	4.8	5.1***
Soil fertility concern score	10.3	10.3ns	10.8	10.1***	9.6	10.1***
Viability - long term financial viability score	2.5	2.2***	2.5	2.2***	2.6	2.1***
Land stewardship score	4.2	6.8***	5.9	5.4*	4.4	7.0***
<b>Situational characteristics</b>						
Equity %	86.6	85.1*	84.7	87.6***	87.3	85.4**
Total farm debt \$'000	105	185***	123	156***	107	178***
Market value of farm \$'000	705	1,094***	665	1,144***	763	1,060***
Growing season rainfall April – Oct (mm)	287	318***	310	286***	296	309***
Arable area (ha)	1374	1236**	1594	1236***	1270	1296ns

**TABLE 4.1 continued**

Variable	Adoption of innovations		Production capability (potential wheat yield)		Innovativeness	
	Bottom 25%	Top 25%	Bottom 25%	Top 25%	Bottom 25%	Top 25%
<b>Production characteristics</b>						
Average wheat yield (t/ha)	1.9	2.5***	1.5	2.8***	2.0	2.4***
Potential wheat yield (%)	54.6	62.1***	37.7	81.2***	55.0	61.8***
Total area in crop (hectares)	683	846***	809	816ns	692	833***
Cropping intensity (% total area)	54.3	67.6***	52.9	68.7***	57.7	64.2***
Total grain produced (tonnes)	997	1658***	1011	1681***	1123	1536***
Crop area sown to broad leaf crop (%)	12	23***	11	22***	12	23***
<b>Adoption characteristics (best practice score)</b>						
Crop establishment	3.5	4.5***	3.8	4.2***	3.8	4.2***
Crop nutrition	2.6	3.4***	3.0	3.1***	2.7	3.3***
Pest management	3.9	5.2***	4.3	4.6***	4.3	4.7***
Grain marketing	2.7	3.6***	3.1	3.3***	3.9	3.4***
Rotation management	2.2	2.8***	2.5	3.7***	2.3	2.7***
Full adoption innovation	5.4	14.1***	8.8	10.7***	9.6	11.9***
Time lag to adoption	463	508ns	477	500ns	445	593***
<b>Information sources (number)</b>						
Printed information sources	52.6	71.7***	60.6	66.6***	53.8	71.4***
Electronic information sources	26.2	32.0***	29.6	30.7ns	28.3	30.4**
Personal information sources	41.9	65.6***	53.1	57.3*	48.2	60.3***
Group participation	2.4	3.7***	3.0	3.3***	2.3	3.8***
Field day attendance	7.9	7.0***	7.8	7.0***	7.5	7.1**

The relationships between group means was analysed using the T-test. (F values: ns=not significant \*=significant p<0.1, \*\*=very significant p<0.05, \*\*\*=highly significant p<0.001). Note the 'n' values for each of the values in the Table is > 400.

#### **4.6.1 Adoption of innovation – quartile comparisons**

Those respondents referred to as high adopters (who were in the top 25% quartile for level of adoption of innovations) were found to be younger with less farming experience than low adopters (respondents in the bottom 25%). High adopters were less conservative, more positive about the long-term outlook of farming (farm financial viability) and had a higher land stewardship score. In terms of equity high adopters had lower equity (85.1% in comparison to 86.6%) but had significantly higher borrowings (\$185,000 compared to \$105,000) and property value (\$1,094,000 compared to \$705,000).

Higher adopters were found to farm in more favourable agricultural environments, reflected through them receiving significantly higher rainfall (318mm compared to 287 mm received by low adopters) and achieved significantly higher wheat yield (and potential crop yield based on rainfall). High adopters sowed a higher proportion of broadleaf crops (23% total area in comparison to 12%) and produced significantly greater tonnage of grain (1658 tonnes of grain per annum in comparison to 997 tonnes of grain) than low adopters. High adopters had significantly higher adoption scores, greater number of information sources, and participation in-group activities than the low adopters. This reflects in part the hidden costs associated with non-adoption, particularly when comparing the total level of grain production between the top and bottom quartiles of the segmented population.

#### **4.6.2 Production capability (potential wheat yield achievement) – comparison of quartiles**

High yield achievers (described as those respondents in the top 25% of potential wheat yield achieved) were found to be younger in age than the low yield achievers. High yield achievers had greater concerns towards soil fertility and were far less conservative, whilst having far greater equity in their farm business (with significantly higher property values). High yield achievers had less growing season rainfall, less arable cropping area available to them and attained an average crop yield potential of 81.2% in comparison to low yield achievers having just 37.7%. Both groups had no significant difference

in crop area however high yield achievers had significantly higher cropping intensity (68.7% of total arable area under crop in comparison to 52.9%). High yield achievers produced significantly more grain per annum, 1681 tonnes in comparison to 1011 tonnes. High yield achievers had significantly higher levels of adoption of all cropping practices. There were no differences between groups in terms of access to electronic information sources; however high yield achievers had significantly higher levels of access and participation to printed information and group participation.

Results suggests that if we can provide higher levels of support to those farmers that are in the bottom 25% quartile, there are significant production gains to be made, as there are no significant differences between the two groups in relation to rainfall and land area. These observations also dispel the fact that supporting agronomic extension will not result in significant returns on investment (through increased production). If no action is taken, there is a serious risk of a 'productivity divide' widening between those that have the capability of producing high returns through production, and those who cannot.

#### **4.6.3 Level of innovativeness – comparison of quartiles**

Innovative farmers are described as those respondents in the top 25% quartile (relating to their score for innovativeness) whilst conservative farmers are those found in the bottom 25% quartile of the population (negative relationship to innovativeness scores). Innovative farmers were found to be significantly younger with less farming experience than the conservative farmers. Innovative farmers were more concerned about soil fertility, had a significantly higher land stewardship score and were less concerned about their long-term financial viability. Conservative farmers had slightly higher equity levels and significantly lower debt levels and farm value. Conservative farmers were more likely to be found in low rainfall environments (receiving less growing season rainfall). There were no differences in farm area between the two groups, although innovative farmers had significantly greater crop area, sowing intensity, grain production and area sown to broad leaf crop than conservative farmers. Innovative

farmers had significantly higher levels of adoption, access to information sources and participation at field days and in-group based activities.

It is evident that the environment in which farmers operated had an influence over their behaviour. Those farming in environments receiving higher rainfall tended to be more innovative, and more likely to adopt technologies. Farmers operating in low rainfall environments were likely to be more conservative, and have lower levels of adoption. When the population was segmented on the basis of crop yield potential achieved, it was found that those who were in the top 25% farmed in environments receiving slightly less rainfall than the bottom 25% of potential yield achievers. This indicates that in many instances there are greater levels of potential crop yield efficiency achieved in the lower rainfall environments (i.e. farmers make use of all available moisture), despite other relationships indicating lower levels of adoption of many practices. Whilst farmers may be perceived to be less successful (in terms of the number of farming practices adopted and their conservative attitudes), their approach to managing risk was assisting them in being highly efficient in terms of crop water use and corresponding potential crop yields that were being achieved.

#### **4.7 PRINCIPAL COMPONENT ANALYSIS (PCA)**

Several PCA runs were conducted, with a range of variables. Selection of the variables proved to be critical in ensuring that the results obtained from the analysis met the following criteria;

- Minimised the exclusion of respondents data from the analysis (due to missing values);
- Provided high levels of data reliability;
- Results were linked to the hypotheses and could be interpreted with high levels of confidence;
- Variables were not derived from other variables used in the analysis

It was a matter of trial and error in terms of experimenting with data sets (associated with the variables) in order to identify a final set of variables for analysis (presented in Table 4.2).

**TABLE 4.2: Variables selected for the final principal component analysis**

Variable	Description
1. Years involved in farming	Reflects level of experience and age, nominal data
2. Education	Level of education
3. Conservatism	Degree of conservatism linked to attitudinal responses
4. Long term viability	Confidence in the long term viability of the farm business
5. Equity	Percentage equity in the farm business as a financial indicator
6. Arable area	Total area of farm suited for cropping
7. Growing season rainfall	Rainfall received from April to October (inclusive)
8. Wheat yield	Average wheat yield of crops (tonnes per hectare)
9. Best practice score	Total best management practices adopted (weighted according to full, partial or dis-adopted)
10. Information sources	Total number of different information sources accessed
11. Average time lag to adoption	Time between initial awareness and adoption of the practice

#### 4.7.1 Rationale for the selection and / or exclusion of specific variables

The total number of variables chosen was influenced by the actual eigenvalues of the specific correlation matrix obtained for each PCA run. In general the fewer the number of variables used in the analysis the greater the cumulative values associated with each of the principals, thus explaining variability in the specific data set. Each specific principal component was studied in order to identify those dominating variables that characterised each of the principal components. A small number of variables were withdrawn from the analysis to reduce possible duplication (and achieved a more robust data set through the analysis). Specific variables removed from the analysis and rationale for exclusion were as follows:

- Age - high levels of correlation between age and number of years involved in farming;
- Potential wheat yield - was withdrawn since wheat yield remained in the analysis;

- Best practice was used as an indicator of the cumulative number of technologies that had been adopted by the respondent, resulting in the ability to exclude specific practices; and
- The total number of information sources was included as a reflection of the ability to access information from a range of different sources (including group participation and field days).

#### 4.7.2 Interpretation of principal component analysis (PCA)

Eigenvalues associated with the correlation matrix are presented in Table 4.3. The variance within the population (as reflected in the cumulative values of the principal components) indicates that the first four principal components account for 60% of the variance within the population analysed.

**TABLE 4.3: Eigenvalues for the principal component analysis**

	<b>Eigenvalue</b>	<b>Difference</b>	<b>Proportion</b>	<b>Net %</b>
Principal component 1	2.35	0.45	0.21	21.3
Principal component 2	1.90	0.61	0.17	38.6
Principal component 3	1.29	0.24	0.12	50.4
Principal component 4	1.05	0.04	0.10	59.9
Principal component 5	1.01	0.19	0.09	69.1
Principal component 6	0.82	0.19	0.08	76.6
Principal component 7	0.64	0.04	0.06	82.3
Principal component 8	0.60	0.06	0.05	87.7
Principal component 9	0.54	0.02	0.05	92.6
Principal component 10	0.51	0.21	0.05	97.2
Principal component 11	0.32		0.03	100

#### 4.7.3 Describing the characteristics associated with the principal components

Whilst a considerable portion of the variability in the population can be explained by the first four principals (accounting for 59.9% variance), it is necessary to look at characteristics associated with each principal component in order to understand the influencing variables within each principal. The value for

the association between each principal and the variables used are presented in Table 4.4 (and graphically in Figure 4.51).

**TABLE 4.4: Value of variables associated with each principal component (values > +/-0.3 are in bold, blue being positive, red negative).**

Variable	Principal component 1	Principal component 2	Principal component 3	Principal component 4
Years involved in farming	-0.229	0.294	<b>0.464</b>	<b>0.350</b>
Education level	0.300	-0.260	<b>-0.400</b>	-0.202
Innovativeness score	<b>0.401</b>	<b>-0.306</b>	0.071	-0.007
Viability	-0.183	0.075	<b>-0.345</b>	<b>0.650</b>
Equity	-0.010	0.140	<b>0.530</b>	<b>-0.361</b>
Area (ha) arable production	-0.151	<b>-0.481</b>	0.300	-0.009
Growing season rainfall	<b>0.342</b>	<b>0.484</b>	-0.063	-0.044
Current wheat yield	<b>0.442</b>	<b>0.416</b>	0.014	-0.023
Total information sources	<b>0.353</b>	-0.282	0.277	<b>0.388</b>
Adoption best practice score	<b>0.448</b>	-0.081	0.220	<b>0.340</b>
Time lag adoption technologies	0.052	-0.052	0.068	-0.125
Level of variance accounted for by each specific principal (%)	21	17	12	10

#### 4.7.4 General descriptions of the principal components

Based on the scores obtained from the PCA (as presented in Table 4.4) the most dominant variables for each particular principal component are presented in the following text. This will help to explain the nature of the variability in the population analysis.

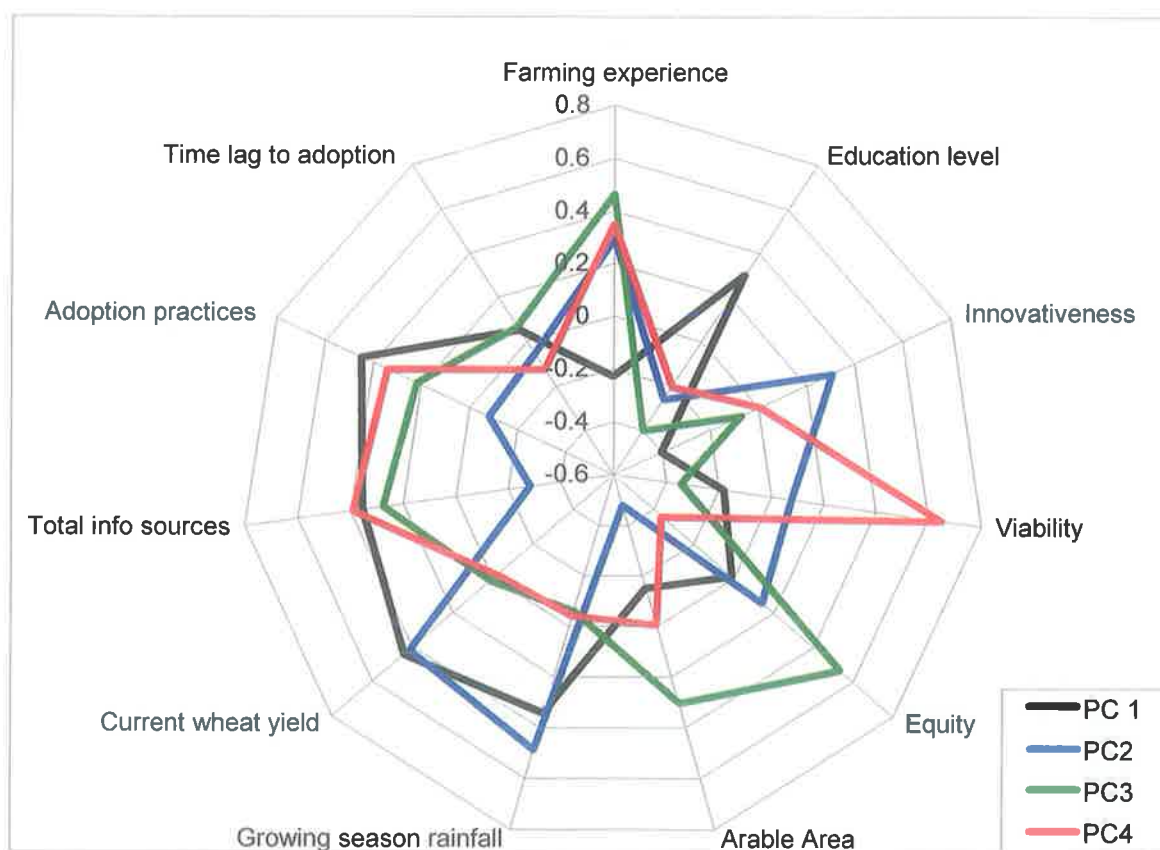
**Principal component 1:** Influencing variables include high adoption, high productivity, high rainfall (reliable farming district) ready access to information, innovativeness and less experience in farming.

**Principal component 2:** Influencing variables include low crop area, high rainfall, high crop yield, lower education and less access to information.

**Principal component 3:** Influencing variables include high equity, high levels of experience and low education.

**Principal component 4:** Influencing variables include viability concerns, lower equity, readily access information, and high adoption.

**FIGURE 4.50: Graphical representation of the four principal components**



#### 4.8 K-MEANS CLUSTER ANALYSIS RESULTS

Cluster analysis allowed the sorting of respondents into clusters based on the groupings having strong elements of association. As part of the k-means cluster analysis, several runs were performed in order to identify optimum number of clusters. Determination of the optimum number of clusters for analysis can be subjective in nature. One of the main factors taken into consideration is the resultant size of the clusters. Few cluster numbers may result in the loss of specificity associated with cluster characteristics. This is evident in relation to analysis that results in large cluster numbers (as illustrated in Table 4.5 with the first run involving 8 clusters having one cluster dominated by 508 respondents). Analysis with few clusters also poses the danger of bringing clusters together that otherwise may have greater variance in relation to specific variables (than where runs with larger cluster numbers are permitted). Once clusters are isolated it is possible to examine the characteristics and likeness of each.

**TABLE 4.5: K-means cluster analysis results for the different cluster runs**

Cluster Number	Number of respondents in each of the different clusters		
	8 clusters	10 clusters	15 clusters
1	165	19	102
2	22	83	65
3	508	337	64
4	41	25	139
5	232	23	24
6	35	233	118
7	78	44	7
8	24	76	123
9		200	5
10		76	70
11			297
12			5
13			27
14			19
15			51

There are general stopping rules associated with cluster analysis based upon the variance by group size and resulting group size. This however is less of an issue with the k-means cluster analysis, due to an iterative reallocation procedure based on variance optimization of mean values. Results in relation to the number of survey respondents for three analysis runs (with 8, 10 and 15 clusters) are presented in Table 4.5. It was determined that by running the k-means cluster analysis with 10 pre-determined clusters, cluster sizes generated were considered a satisfactory compromise between cluster number and size, and provided a meaningful analysis and interpretation of characteristics associated with the clusters generated through analysis.

Based on the k-means cluster analysis (for the run of 10 groups) scores for each of the variables were calculated and results are presented in Table 4.6. Results feature average scores for each of the variables across the different cluster groupings in addition to the variance from the mean value. This helped to provide an objective means of interpreting and describing the characteristics associated with the measured variables for each cluster group.

A brief description of the characteristics associated with each cluster is provided in Table 4.7 and provides an overview of the major characteristics that differentiate each cluster from one another.

A summary of the key differences between the clusters is presented in Table 4.8. For each cluster a summary of the variance about the mean for the measured variables are presented by way of a colour coded chart. If there is little variance (within +/- 0.5 of the mean, the respective cluster cell is yellow, > 0.5 as green, and > -0.5 as red.

**TABLE 4.6 Cluster analysis score for each cluster**

Specific variable measured	Cluster number									
	1	2	3	4	5	6	7	8	9	10
No. of participants per cluster	19	83	337	25	23	233	44	76	200	76
Years involved in farming (years)	28.2	31.2	26.2	33	33.1	35.9	16.8	23.5	32	15.6
Education score	2.3	3.0	2.7	2.4	3.0	2.2	4.4	3.3	2.8	4.2
Innovativeness score	-3.7	0.5	1.9	-1.0	1.8	-3.0	3.1	-0.6	0.9	2.5
Viability concern score	3.2	2.9	2.0	2.4	1.8	2.5	2.0	3.5	2.0	1.9
Equity in farm business (%)	48.1	71.5	88.1	88.8	87.8	90.2	90.5	84.8	91.2	67.2
Arable land area (ha)	869	981	1597	1372	4935	1175	1084	982	799	1206
GSR April–Oct (mm)	304	349	280	300	234	289	323	296	367	308
Wheat yield (t/ha)	1.93	2.76	1.97	1.89	1.38	1.82	2.67	2.12	3.19	2.21
Information access score	16.3	27.5	26.1	22.9	24.9	16.9	26.6	22.7	23.3	22.7
Adoption best practice score	16.0	19.5	18.5	16.6	17.2	14.9	19.0	18.0	18.7	17.2
Time lag to adoption (days)	263	625	536	3134	294	400	1826	203	383	312
<b>Variance about the mean (standardised scores) (values &gt; 0.8 from the mean highlighted in blue, values &gt;-0.8 highlighted in red)</b>										
Years involved in farming	0.09	0.53	-0.19	0.78	0.79	1.19	-1.53	-0.58	0.64	-1.71
Education	-1.00	-0.09	-0.41	-0.84	-0.10	-1.06	1.84	0.41	-0.34	1.55
Innovativeness score	-1.71	0.10	0.72	-0.56	0.69	-1.40	1.26	-0.36	0.27	1.00
Viability concerns	-1.22	-0.86	0.69	0.03	1.04	-0.16	0.75	-1.84	0.76	0.82
Equity in farm business	-2.31	-0.66	0.51	0.56	0.49	0.66	0.68	0.28	0.73	-0.96
Arable land area	-0.51	-0.42	0.08	-0.10	2.79	-0.26	-0.34	-0.42	-0.57	-0.24
GSR April –October	-0.04	1.20	-0.69	-0.14	-1.92	-0.44	0.50	-0.26	1.69	0.09
Wheat yield	-0.49	1.06	-0.42	-0.57	-1.52	-0.70	0.89	-0.14	1.87	0.03
Information access score	-1.77	1.19	0.82	-0.02	0.49	-1.62	0.96	-0.07	0.08	-0.07
Adoption best practice	-1.10	1.32	0.68	-0.69	-0.26	-1.82	1.00	0.34	0.77	-0.23
Time lag to adoption	0.53	0.16	0.25	-2.45	0.50	0.39	-1.09	0.81	0.41	0.48

**TABLE 4.7: Characteristics of the different clusters from the analysis**

<b>Cluster Number</b>	<b>% of population</b>	<b>Description of main distinguishing features</b>
1	1.7 (n=19)	Extremely low equity, very low innovativeness, minimal access to information, low adoption of best practices, low education, not greatly concerned about future business viability
2	7.4 (n=83)	Above average growing season rainfall, high wheat yields, very high access to information, very high adoption of best practices, moderate concern towards future business viability, very low equity, above average farming experience
3	29.9 (n=337)	Below average rainfall and wheat yields, above average information access and adoption of best practices, above average equity, above average concern towards future business viability
4	3.1 (n=25)	Very slow to adopt new technologies, low education, low innovativeness, low wheat yields achieved, below average adoption of best practices, above average experience, equity levels above average
5	2.0 (n=23)	Extremely low rainfall environment, extremely large land areas, below average wheat yields, above average information access, lower levels of adoption of best practices, concerned about future business viability
6	20.7 (n=233)	Very low adoption of best practices, very low level of innovativeness, very low access to information, very low education, below average wheat yields, slightly above average business equity, high farming experience, smaller land size
7	3.9 (n=44)	Low experience in farming (younger age), high education, extremely innovative, high information access and adoption of best practices, small land size
8	6.7 (n=76)	Low innovativeness, above average equity, low concerns relating to future business viability, above average adoption, slower to adopt, below average land size
9	17.7 (n=200)	Very high rainfall, very high wheat yields, above average adoption of best management practices, above average business equity, future business viability concerns, above average farming experience, below average education
10	7.0 (n=76)	Very low experience in farming (younger farmer), very high education, very innovative, very low business equity, more selective in the adoption of best management practices, whilst being quick to adopt practices
Total (n=1128)		

**TABLE 4.8 Summary of influencing factors from the cluster analysis**

Influencing factor	Cluster number									
	1 (n=19)	2 (n=83)	3 (n=337)	4 (n=25)	5 (n=23)	6 (n=233)	7 (n=44)	8 (n=76)	9 (n=200)	10 (n=76)
Age*	Yellow	Red	Yellow	Red	Green	Green	Green	Green	Red	Green
Education	Red	Yellow	Yellow	Red	Yellow	Red	Green	Yellow	Yellow	Green
Innovativeness score	Red	Yellow	Green	Red	Green	Red	Green	Yellow	Yellow	Green
Viability concerns	Red	Red	Green	Red	Green	Yellow	Green	Yellow	Yellow	Green
Equity in business	Red	Red	Green	Green	Yellow	Green	Green	Yellow	Green	Red
Farm area (arable)	Red	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Red	Yellow
Rainfall	Yellow	Green	Red	Yellow	Red	Yellow	Green	Yellow	Green	Yellow
Wheat yield	Yellow	Green	Yellow	Red	Red	Red	Yellow	Yellow	Green	Yellow
Information access	Yellow	Yellow	Green	Red	Yellow	Red	Green	Yellow	Green	Yellow
Adoption best practice	Red	Green	Green	Red	Yellow	Red	Green	Yellow	Yellow	Yellow
Time to adoption	Red	Yellow	Yellow	Green	Yellow	Yellow	Green	Red	Green	Yellow

Table key

- +/- 0.5 of the mean
- > 0.5 of the mean
- > - 0.5 of the mean



Note: the “time lag to adoption” scores are presented as an inverse relationship, that is a negative score > -0.5 variance about the mean is represented in green, and a positive result (>0.5) is represented in red.

\*Age is derived from farming experience, green = younger farmer, red= older farmer).

#### 4.8.1 Characteristics associated with each of the cluster groups

From the analysis, the key relationships and characteristics associated with each of the clusters are summarised. Each cluster is compared relative to one another.

#### Cluster 1

Farmers have extremely low equity, very low innovativeness, minimal access to information sources, low adoption of practices, low education, and limited concern toward future business viability. These farmers do not have a positive future.

#### Cluster 2

Farmers receive above average rainfall, achieve high wheat yields, have very high access to information, have very high rates of adoption of practices, have moderate concern towards business viability, very low equity, below average farm area, above average farming experience. Farmers are likely to be older, from a well-established and reliable farming environment. Whilst readily adopting technologies and accessing information, longer-term viability is questionable.

#### Cluster 3

Farmers receive below average rainfall, with wheat yields also below average. These farmers are also found to have above average information access and adoption of practices. Whilst they have above average equity, they have low levels of concern in terms of business viability. Overall this cluster may be considered representative of the average profile of respondents (due to low variability of results about mean values).

#### Cluster 4

Farmers are very slow to adopt new technologies, having low levels of education. These farmers are also considered to have low levels of innovativeness, and are likely to have below average rates of best practice adoption. They generally achieve low wheat yields, whilst having have above average farming experience and above average equity levels.

#### Cluster 5

Farmers operate in an extremely low rainfall environment, farm extremely large land areas, and achieve below average wheat yields. Farmers have above average rates of information access, lower levels of adoption of best management practices, and are concerned about business viability. Farmers crop extremely large areas of land in marginal cropping environments.

#### Cluster 6

Farmers have very low adoption of practices, characterised by very low level of innovativeness. Farmers also have very low access rates to information, very low education and produce below average wheat yields. Business equity levels are slightly above average, they have high levels of farming experience and their farms are smaller in land area. Farmers in this cluster may be at the end of their career, with no real pressures to change their farming behaviour, due to their financial security.

#### Cluster 7

Farmers in this cluster have low farming experience (younger age), above average education, and are considered to be extremely innovative. They have high rates of information access and adoption of practices. Farms size is generally smaller, whilst they have good equity in their farm business. They are generally establishing themselves as farmers, having a sound base for future expansion.

#### Cluster 8

Farmers have low innovativeness, above average business equity, with low concerns relating to future viability. Farmers have above average adoption rates whilst slower to adopt. Land area is below average. Farmers tend to be in the middle age range (based upon level of experience), and are willing to consider change on-farm.

#### Cluster 9

Farmers operate in a very high rainfall environment and achieve very high wheat yields. These farmers have above average adoption rates, with above average business equity. They are concerned about their future viability. These farmers are found to have above average farming experience but below average education. These farmers are generally successful, and are farming in a relatively secure environment, though opportunities for future expansion on-farm is limited.

#### Cluster 10

Farmers have very low experience in farming (younger farmer), with very high levels of education, and are considered to be very innovative. They have low business equity levels, with moderate levels of practice adoption. These farmers may be involved in a process of farm build-up, reflecting higher debt levels and lower equity levels. Whilst they have moderate levels of adoption, they are usually quick at adopting the practice once they have made the decision to do so. This may indicate that they are more selective in their adoption behaviour.

### **4.9 DISCUSSION**

Outcomes from this study have indicated that in order for practices to be adopted on-farm, a number of requirements need to be addressed. These include characteristics associated with the farmer (farming skill capability, decision-making skills, attitudes to innovation and education level), the nature of the agricultural knowledge system, characteristics associated with the technology and the management of risk. These aspects form the basis of the discussion presented in the following text.

#### **4.9.1 Influence of personal and situational characteristics on the adoption of technologies**

It is evident that there is significant variability across the research population in terms of situational characteristics, the relative productivity and the production capacity of farmers. Quartile comparisons of production capacity (based upon growing season rainfall and resultant yield potential achievement) indicated significant differences in production achieved. The bottom 25% of the survey population on average produced 1011 tonnes of grain, compared with the top 25% who produced 1681 tonnes of grain. Similarly quartile comparisons relating to level of innovativeness identified significant differences associated with productivity, adoption of practices, financial performance, risk aversion, access to information and group participation. Whilst average yields across South Australia have increased at a rate of 30kg/ha/annum in the 20 years to 2000 (Turner and Asseng 2005), the full potential may not have been achieved due to the failure to develop a strategically focussed change process that is sympathetic to the socio-economic characteristics of the farming population. It is this factor that may influence the variability in productivity across the survey population.

As a result, there are a number of implications that need to be considered when developing strategies for extension, in terms of how individuals differ in their response to different practices, preferred sources of information and their capacity and capability to embrace change on-farm. It is important to note that not all farmers and farm businesses are alike. Variability in productivity and yield potential achieved between respondents is indicative of different levels of personal capability and productive capacity to produce grain. An understanding of this will emphasise the need to develop tailored and targeted extension messages and programs, rather than taking the approach of "one size fits all" to developing extension programs.

These conclusions are supported by Guerin (2000) who considered that the most important factors that influenced the adoption of innovations related to the personal characteristics of the farmer and

the environment they operated in. The personal and situational characteristics of farmers themselves are indeed complex. The study has been successful in identifying critical factors that differentiate the adoption behaviour and the level of farm productivity amongst farmers. Kalirajan and Shand (2001) described three factors associated with highly productive farmers as being profit-seeking behaviour, technical efficiency and resource use efficiency – similar characteristics were identified with the higher achieving farmers associated with this research study. The level of formal education likewise has been identified as influencing the level of adoption of innovations in this study and work conducted by Kremer et al. (2001), Guerin and Guerin (1994) and Harper et al. 1990. This research study identified that the high adopters of farming practices tended to have higher debt levels, which is supported by earlier work conducted by Frank (1995b), who found that high adopters tended to operate their farming systems at a higher risk level and were more inclined to borrow additional funds to take on new farming practices.

This study identified a number of significant relationships between personal and situational characteristics. Length of farm ownership for example, was associated with higher levels of business equity, whilst older farmers had lower levels of education. Innovative farmers were characterised by higher levels of education and greater participation in group extension activities and access to information sources. In developing targeted extension programs, it may be preferable to target those farmers who consider themselves innovative in a program aimed at introducing on-farm change. By having an understanding of the audience (and clarity in terms of outcomes to be achieved) it may be possible to better target programs through improved understanding of the behavioural characteristics of the audience. If for example conservative farmers are characterised by low information access scores then creating an awareness of a new practice using traditional information dissemination approaches may be difficult due to limited participation by the targeted audience.

#### **4.9.2 Agricultural knowledge systems characteristics**

It is evident that some information sources provided a baseline of awareness relating to farming practices, such as the Stock Journal, the ABC Country Hour and from other farmers. Such sources were generally accessed by all farmers across the target population, serving as a means for providing an initial awareness of technologies. For some farmers this acted as their only source of information. It also needs to be recognised that there are different avenues of delivery preferred by many farmers. If the preferred means of accessing information through a particular source is known, then this source can be utilised in order to reach the farmer in a targeted manner. The "one size fits all" approach to information delivery is not necessarily one of the most efficient means of achieving practice change. It is therefore important for organisations wishing to influence change at the farm level to utilise a range of approaches to disseminating information. Altering farmer attitude towards particular farming practices and farming systems improvements is not a simple task. It is important to have an appreciation of those sources that are respected by farmers, and which have the potential to influence practice change.

Accessing information is just one stage of the adoption process. Farmers prefer informal information sources supplemented by observation and experiences from other farmers (D'Emden and Llewellyn 2003), as well as utilising print and electronic media sources (Kilpatrick 1999). It needs to be recognised that farmers will seek different sources of information according to the particular stage of the adoption process that they are encountering. Whilst a range of information sources such as the print and electronic media create an awareness of a specific practice, they may not necessarily be the most influential, in terms of achieving adoption as an outcome. Inter-personal influences have an informing role when the farmer is developing an attitude and perception about an innovation. Technical information sources (such as other farmers and specialist consultants) will be critical whilst the "how to implement" phase is being explored by the potential adopter (McBride and Daberkow 2003). Schnitkey et al. (1992) found strong associations between the level of information access

and farmer characteristics such as farm size, type, operator age and computer use; supporting observations made in this study.

The nature of the agricultural knowledge system is complex with a large number of social pressures and inter-relationships, characteristics that were not fully established through the formal survey questionnaire approach. It is evident that further investigation is required in order to capture the influence of social pressures and the dynamics of local agricultural knowledge systems, and will be explored further in Chapter 5 of this thesis.

#### **4.9.3 Technology characteristics and the influence over adoption**

This study identified that characteristics associated with specific practices influenced adoption rates. Relative complexity, ability to integrate within a farming systems context and the risk associated with the specific technology was found to influence the adoption process.

This research study identified that the simple non-complex practices tended to be adopted right across the different rainfall districts. Similarly, Guerin (2001) found that simple innovations were more readily adopted than those considered more complex, whilst Batte and Arnholt (2003) found that there was a reluctance to adopt practices high in complexity such as precision farming unless they were simplified.

This study has established that it is possible to describe farming practices according to their relative complexity and ease of adoption. The more complex technologies pose higher elements of risk, resulting in lower rates of adoption. This is particularly evident in low rainfall farming environments where adoption rates for complex practices are lower (reflective of greater elements of risk). This is not a reflection of the intellectual capabilities of the farmer but a reflection of the greater role (or influence) that risk management plays in marginal farming environments. In essence, there are

logical reasons as to why adoption of particular practices does not occur. Any decision that is made in relation to the adoption of new technologies is considered within a risk management framework at the individual farm business level. The decision to adopt a new farming practice involves a relatively complex set of decision-making processes. These occur within the context of the farmers' own personal and situational factors. The farmers' attitude to new technology, risk management capabilities, conservatism and business environment will all play a role in the final decision relating to the adoption or rejection of an innovation.

#### **4.9.4 Managing risk as a logical response to adoption**

The management of risk by farmers influences adoptive decisions by farmers. This is more evident in low-rainfall farming environments, where there is a tendency for reduced uptake of the more complex technologies; often perceived to be associated with higher elements of production risk amongst farmers. There are logical reasons as to why non-adoption and dis-adoption take place. Outcomes from this research study have established that the nature of the innovation in terms of relative complexity and ease of adoption will influence the level of adoption. Not all of the farming audience have the desire (or the capacity) to adopt new practices and many are quite comfortable with their current systems (linked to specific life-stages). Older farmers being less likely to adopt due to their higher levels of risk aversion and conservatism.

Comparisons in relation to the adoption of a range of farming practices across different rainfall zones identified variability in adoption rates. Practices that achieved relatively high levels of adoption in high rainfall districts, achieved extremely low rates of adoption in marginal and to a lesser extent low rainfall districts, and included use of narrow points on seeding equipment, gross margin planning, grain marketing plans, plant tissue testing and sowing pasture legumes. In relation to use of narrow points on seeding equipment (utilised in no-till systems) survey results identified that the level of adoption in marginal cropping districts was 13%, compared with high rainfall districts of 80%. Similar

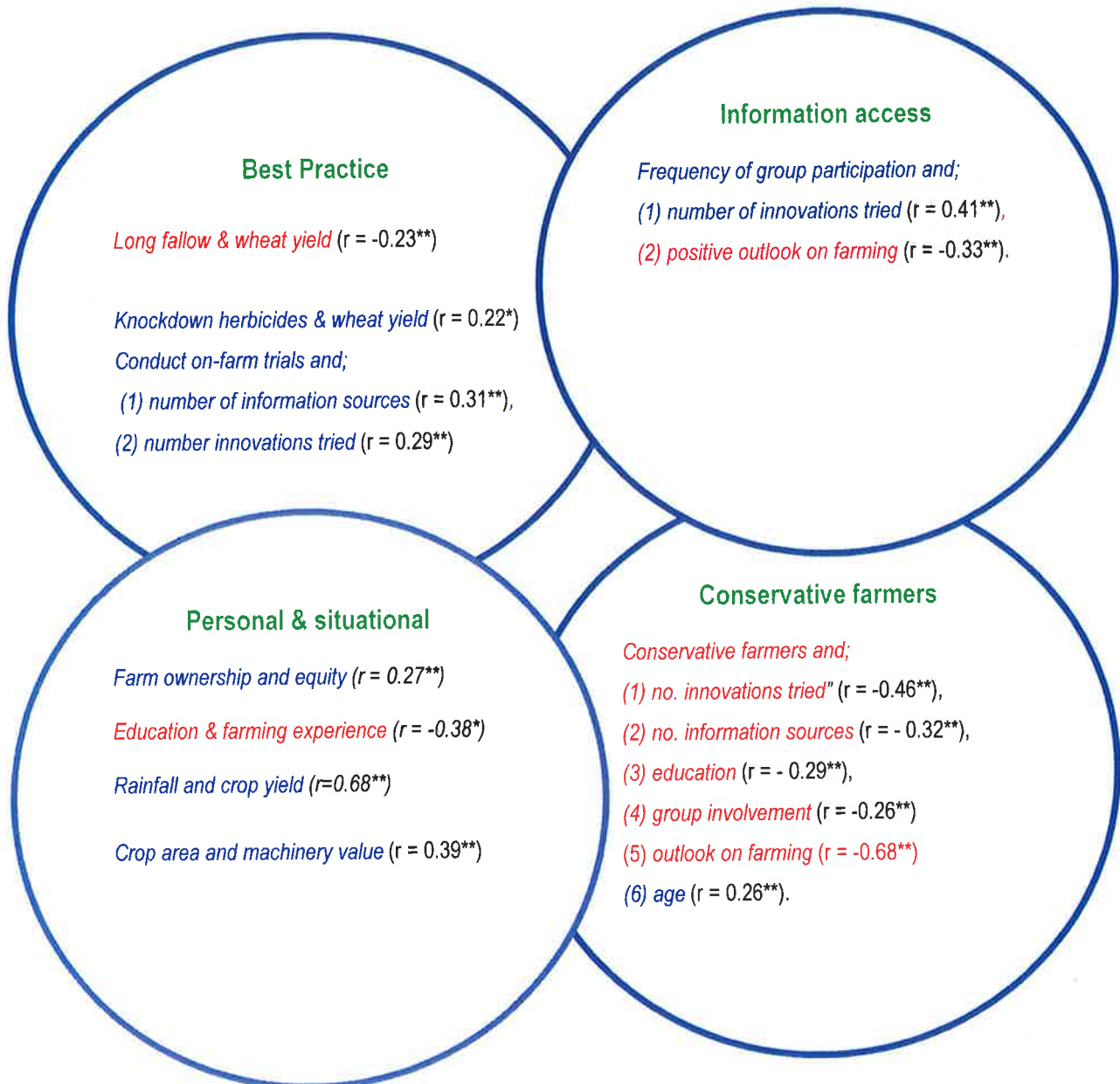
findings have been made in other research studies. A survey conducted in 2003 amongst SA farmers identified adoption rates of no-till seeding systems ranged from 20% in the northern Mallee (marginal rainfall district) up to 80% in the Mid North district (higher rainfall) (D'Emden and Llewellyn 2003).

It could be argued that the level of adoption of a range of best management practices may be a reflection of the relative complexities of the specific farming systems (availability of a range of crops for different rainfall zones), attitude to risk, and exposure of farmers to the range of practices surveyed. These conclusions are supported by Pannell and Zilberman (2000) who found that farmers preferred to avoid adopting practices often due to the complexities associated with the specific technologies, and the lack of observability associated with a given problem.

#### **4.9.5 Sequential adoption of best management practices**

Analysis of relationships between best practices identified that adoption tended to occur in related groupings (refer to Figure 4.51), indicative that farmers generally took a sequential approach to adoption, and is supported by the work of Doss (2006) who observed that farmers made sequenced adoption decisions in a step-wise manner. As farmers adopted one particular practice, they were found to gain greater confidence in order to adopt the next related farming practice in a step-by-step manner (Leathers and Smale 1991). Similarly the work of Frank (1995a) found that in the development of beef cattle properties there was an orderly pattern of development practices, many of which occurred in logical sets of adoption.

**FIGURE 4.51: Key relationships between a range of variables associated with the population**



red = negative relationship, blue = positive relationship

\* significant at the  $p < 0.001$  level , \*\*significant at the  $p < 0.0001$  level)

#### **4.9.6 Differential attributes of the target population**

Basic tests of association were useful in identifying common linkages between personal and situational characteristics. This provided the opportunity to identify specific characteristics associated with those who had either adopted or who had held innovative attitudes towards farming. It was also possible to identify specific groupings of practices that had been adopted in a collective fashion as part of a managed systems approach to adoption. This approach was limited in illustrating the full dimensionality of the data set; hence PCA and k-means cluster analysis was employed to demonstrate this.

The PCA provided an opportunity to explain the nature of the variability in the population, identifying the most significant characteristics toward population variance. Identified characteristics included levels of adoption, productivity and conservatism (associated with PC1), farm area and rainfall (PC2), equity, experience and education (PC3), and viability and information use (PC4). Collectively the analysis indicated that these four principals accounted for almost 60% of variance in the population (based upon eigenvalues).

The final step in the analysis was the k-means cluster analysis. This technique provided an opportunity to sort the target population into specific groupings or clusters based upon their elements of association (relating to a number of selected variables). This provided an objective means of scoring and identifying specific characteristics of groups that made them unique in relation to other groupings in the population. As a result, it was possible to describe 10 clusters from the population, with each cluster having its own set of unique characteristics (as presented in Table 4.9). Within each cluster, a descriptive name (or farmer typology) has been applied to each cluster, based on the most dominating features of the particular group. This methodology is also described as a market segmentation approach to identifying differing characteristics of a given population.

**TABLE 4.9: Characteristics associated with each of the different clusters from the analysis**

Cluster number	% of population	Description of main distinguishing features
1	1.7 (n=19)	<b>The 'exiting' farmer;</b> extremely low equity, very low innovativeness, minimal access to information, low adoption of best management practices, low education, not greatly concerned in relation to business viability
2	7.4 (n=83)	<b>The 'risk taker' farmer;</b> above average growing season rainfall, high wheat yields, very high access to information, very high adoption of best management practices, moderate concern for business viability, very low equity, above average farming experience
3	29.9 (n=337)	<b>The 'risk manager' farmer;</b> below average rainfall and wheat yields, above average information access and adoption of best management practices, above average equity, above average concern towards business viability
4	3.1 (n=25)	<b>The 'highly conservative' farmer;</b> very slow to adopt new technologies, low education, low innovativeness, low wheat yields achieved, below average adoption of best management practices, above average experience, equity levels above average
5	2.0 (n=23)	<b>The 'marginal cropping lands' farmer;</b> extremely low rainfall environment, extremely large land areas, below average wheat yields, above average information access, lower levels of adoption of practices, concerned about business viability
6	20.7 (n=233)	<b>The 'retired' farmer;</b> very low adoption of best management practices, very low level of innovativeness, very low access to information, very low education, below average wheat yields, slightly above average business equity, high farming experience, smaller land size
7	3.9 (n=44)	<b>The 'young progressive farmer ;</b> younger farmer, high education, extremely innovative, high information access and adoption of best management practices, smaller land size
8	6.7 (n=76)	<b>The 'lifestyle' farmer;</b> low innovativeness, above average business equity, low concerns relating to future viability, above average adoption, slower to adopt, below average land area
9	17.7 (n=200)	<b>The 'gentry' farmer;</b> very high rainfall, very high wheat yields, above average adoption of best management practices, above average business equity, future viability concerns, above average farming experience, below average education
10	7.0 (n=76)	<b>The 'young battling' farmer;</b> younger farmer, very high education, very innovative, very low business equity, lower levels of adoption of best management practices
Total (n=1128)		

The cluster analysis illustrated that farmer age features prominently in distinguishing the characteristics between the different clusters. Older farmers were a feature in three of the clusters (clusters 1, 4 and 6, comprising 25.8% of the survey analysis population). Accompanying

characteristics included a low level of innovativeness, low rates of adoption and low rate of information access. In contrast to this, younger farmers (with associated characteristics of high information access, higher rate of adoption and innovativeness were associated with three clusters (5, 7 and 10, comprising 12.9% of the population). These observations are supported by studies undertaken by Walker et al. (1997) who found that less experienced, young growers were more willing to take on new integrated pest management technologies. For the remaining clusters (2, 3, 8 and 9) age was not a determining factor, with the main influential characteristics being rainfall, information access and adoption of farming practices.

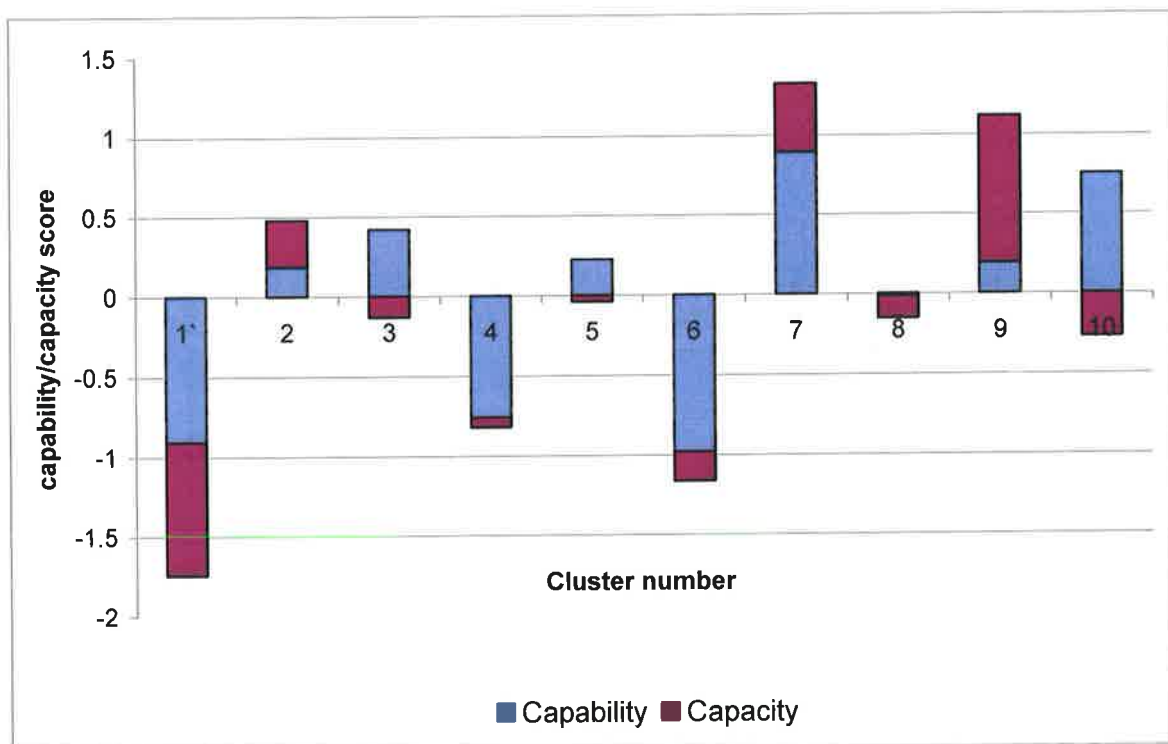
In relation to clusters 1 and 6, it is evident that they lack the capacity and capability to embrace change, reflected through a number of characteristics that in many instances include their relative small scale of operations, low equity and concern for business viability, lower levels of information access and lower rates of adoption. Similar conclusions were reached in relation to studies conducted by Mariger and Kelsey (2003), where they identified disengaged farmers within a target population as being characterised by few information sources, little communication with the local farming community, smaller farm size, lower education levels and low levels of adoption.

It has become clear there are two key characteristics associated with the population that have influenced differentiation between segmented groups, these being the capacity and the capability to manage and respond to change. As a means of conceptualising the relationships between the levels of capability and capacity associated with each of the clusters, a graph summarising the distinguishing characteristics (in terms of capability and capacity) between each of the clusters is presented in Figure 4.52, building on the findings derived earlier in this study. This provides an indication of the relative levels of capacity and capability associated with each cluster, and is presented as a score. The scoring system for each cluster is derived from the variance about the mean for a range of measurements (used in the cluster analysis) that are representative of the levels

of capacity and capability associated with each clusters. Variables used in derivation of the capability score were number of years involved in farming, level of education attained, level of innovativeness, viability concerns, information access, level of adoption of best practice, and time lag to adoption. Variables used in the capacity score comprised equity in farm business, arable area of farm, growing season rainfall and wheat yield attained.

The graph presented captures the key characteristics and influences associated with each of the clusters, and is useful in demonstrating relationships between capacity and capability levels. Clusters 1, 4, 6 and 8 all had negative values for both capacity and capability. Clusters 2, 3 and 5 had low scores for capability. Clusters 3, 5, 8 and 10 had negative scores for capacity, whilst only clusters 7 and 9 had positive scores for both capacity and capability.

**FIGURE 4.52: Conceptual model providing comparisons in relation to the positioning of the identified clusters, according to their balance between capacity and capability.**



This analysis has provided an ability to objectively examine the characteristics of specific groupings of the population arising from the k-means cluster analysis. The characteristics of these groups have been described in a manner in which the adoptive behaviors of the groups can be interpreted within a logical framework. The adoption behaviour of any given population of farmers may be influenced by the uniqueness of their personal and situational characteristics. It has been possible to develop a better understanding of the adoptive behaviour of the farming community, through applying a holistic approach to exploring the nature of adoption and characteristics of the target population.

#### **4.10 COMPARISON OF THIS STUDY TO OTHER SIMILAR RESEARCH**

This study has identified specific clusters of farmers through multi-variate analysis techniques supported through k-means cluster analysis. Such an approach to analysis of large data sets is a common characteristic of a market segmentation approach to identifying groupings within a population. Recent studies have identified specific groupings of farmers derived through multivariate analysis tools (e.g. principal component analysis and k-means cluster analysis). Appendix U provides a comparison of a number of studies relating to identification of farming typologies, based upon socio-economic influences and derived through principal component analysis and/or k-means cluster analysis.

Research work conducted by Emtage and Suh (2005) aimed to identify the typology of households located in the rural areas of the Philippines, on the basis of characteristics associated with their farming and livelihood systems. Analysis of the data using the k-means cluster analysis provided the opportunity to capture typologies that were not known nor pre-conceived in an exploratory manner. The work of Emtage and Suh (2005) identified five different types of farmer typology. This was undertaken through a process of describing and comparing socio-economic and behavioral characteristics in each of the different typologies. The study concluded that research and policy development needed to create a set of conditions in which the adoption of practices could be

performed, and which satisfied the differing needs of the typologies described. Whilst the work of Emtage and Suh (2005) focused on an entirely different environment (the adoption of forestry management practices) to that of this research program, it is interesting to note that similar approaches and outcomes to this study were undertaken with similar outcomes achieved. This occurred independent of one another, and demonstrates the level of rigour and approaches adopted in both studies. The Philippines study however was limited to a much smaller target population, involving 203 households, compared with this study that utilised the characteristics associated with 2472 farming businesses.

The identification of five different farmer typologies associated with Dutch farmers formed the focus of research work conducted by de Lauwere (2005) describing typologies derived from k-means cluster analysis. Typologies were described as social, traditional, new, indecisive or prudent farmers. This research work involved the collection of data on the basis of farmer responses to a series of attitudinal questions. The study involved a smaller population of farmers (752 in total) and utilised a similar approach to data analysis to this thesis, concluded that personal characteristics play an important role in describing the various farmer typologies associated with the target population.

Gunderson et al. (2005) conducted a market segmentation study focusing on the capital expenditure characteristics associated with a population of 2000 agribusiness customers. This study was driven by a marketing orientation that aimed to segment the audience based on identifying the relative profitability gains that were expected to be made from specific segments of the population. Cluster analysis used a number of different variables (including farm size, age, education, internet use, technology adoption rate, local supplier loyalty, and purchasing behaviour). The analysis identified four clusters, these being relationship, economic, business and balanced buyers. This model then allowed the agribusiness company to create a customer scorecard used to effectively manage profitability through targeted marketing activities based upon anticipated behavioural responses.

Whilst this study had a strong marketing orientation the approach had similar characteristics undertaken in this research study. The outcomes and motivations between the two studies are different, but have a common goal to change behaviour.

There have been numerous studies that have only focussed on part of the adoption environment. These studies have been limited in terms of what they have discovered, and the significance of outcomes achieved in terms of explaining overall behaviour. Ravnborg and Rubiano (2004) studied the land-use practices adopted by Columbian farmers, revealing that that socio-economic factors were significant for explaining farmer decision-making, as opposed to relying on the physical analysis of land condition.

The work of Michielsens et al. (2002) described specific clusters of Asian fish farmers based on the intensity of their farming system but was limited by the characteristics incorporated into the analysis. Bernhardt et al. (1996) identified the management profiles of farmers, based upon their adoption of a number of different farming practices. A limitation of this research related to researcher bias, as a result of pre-empting categories prior to analysis.

There have been a number of studies conducted in Australia that have focussed on providing descriptors to different farming styles and typologies. Howden et al. (1998) identified specific farming styles predominantly on the basis of qualitative analysis. These styles were largely influenced by the perceptions of farm advisers who provided feedback on a range of farming styles that were originally developed by the researcher. This was followed by focus group sessions with farmers, who were asked to indicate which farming styles best described their behaviour. Many farmers were unable to relate to their own personal characteristics to the farming styles that they were presented with through the focus group studies.

Following on from this, work conducted by Thomson (2001) was able to identify specific groupings of farmers, derived from farmer responses to a range of attitudinal and goal statements. Whilst this process proved to be more robust in its scientific approach than that of Howden, the basis of clustering of the population (using k-means clustering) and subsequent identification of groupings was limited to attitudinal responses to a range of pre-determined statements. Studies conducted by Maybery et al. (2005) amongst 552 Australian farmers by way of survey questions, focus group studies and interviews attempted to identify if farming values could be categorised according to 'economic', 'conservation' and 'lifestyle' goals held by farmers. There was little emphasis in relation to environmental and situational factors that may also influence farmer behaviour, reflecting the limited scope of the study undertaken, in terms of applying a holistic systems approach.

In the approach applied to this thesis the descriptive nature of farmer typologies developed has occurred through a rigorous and credible process, utilising personal and situational characteristics of the target population, supported by statistical analysis procedures. Whilst assigning a description of typology to a cluster group may be viewed as being subjective, such descriptive tagging merely serves as a means to describe the groups in a few key words that capture the dominating characteristics of the group.

#### **4.11 Summary**

Whilst studies relating to the adoption of new technology in the past have tended to focus on the characteristics associated with adopters and non-adopters of technology, this study has been successful in also describing the complete environment in which adoption takes place.

The principal component analysis (PCA) has been useful in identifying the characteristics responsible for variance in the survey population. This is significant in terms of establishing the statistical significance and association between variables and respondents within the survey data

set. Rather than relying upon the perceptions of the researcher, the PCA provided the opportunity to establish the linkages between specific characteristics associated with the target population.

This k-means cluster analysis has provided an ability to objectively examine and interpret the characteristics of groups in the target population. The specific linkages between the variables used provided the basis of establishing significant relationships present in the data set, and population.

This study has also identified that the formation of clusters have been influenced by geographically specific characteristics. This is particularly evident in relation to cluster 2 “big croppers” associated with marginal farming environments and having extremely large farming properties, and cluster 9 the “gentry farmer”, characterised by high rainfall, high rates of adoption. It is important to examine the overall effectiveness of the methodologies and approach taken in this research program, with the view of identifying opportunities for improving such an approach. Comparing methodologies adopted with other studies likewise will also assist in identifying the relative merits and limitations associated with this research approach.

As a result, it has been possible to look at the complete system in a holistic manner, taking into consideration the personal and situational characteristics of farmers involved, using a data analysis tool that has been capable of forming clusters of similar characterised respondents. From this, it has been possible to describe their characteristics and compare these with other groups in the population. This outcome has only possible as a result of undertaking the principal component and k-means cluster analysis. The results obtained identified specific groups of associated variables that otherwise would not have been identified had the analysis been undertaken with a much-limited set of variables.

Results from this study pose a number of implications in terms of how extension programs are best developed and delivered. The k-means cluster analysis has established associations between specific characteristics of the target population, through the identification of specific clusters. As a result a formal segmentation of the population has been established with each group being described. With knowledge of these characteristics, it is now possible to specifically target certain segments of the population for any given extension program. This will assist in the delivery of a specific technology, within the context that takes into consideration the characteristics associated with the targeted market segment.

This research study has also successfully described the clusters of farmers based upon personal, situational characteristics, and adoption behaviour, from an interactive systems perspective. This has resulted in a holistic examination of the adoption environment, resulting in the identification of the adoptive behaviour and intervening variables characteristic of the target population. As a result it has been possible to identify and describe specific clusters of the target population having similar characteristics, indicative of farmer typologies present.

The target of the extension message and the avenue of delivery are both important in achieving adoption. The adoption environment is extremely complex with a wide range of intervening variables and characteristics. Not all respondents will be in a position to adopt; they may not have the desire or the capacity to adopt new technology. Extension delivery systems need to be well targeted, segmentation of the audience will assist in achieving higher levels of adoption success, as well as utilising extension resources more efficiently. The decision amongst those farmers who do not wish to adopt new technologies should be respected. There may however be social pressures that may compel some element of changed behaviour, particularly if the healths of the farmer, others, animals or the environment are at risk. It is the social pressures and interrelationships between different stakeholders that warrant further investigation, particularly within the context of adoptive behaviour

and decision-making processes. Identification of farmer typologies has the potential to better target research, development and extension efforts, particularly if there is likely to be higher rates of adoption leading to greater economic returns in the grains industry.

Chapter five will explore these principles in further detail through the collection and analysis of qualitative information arising from a series of focus group case studies conducted across South Australia. Collecting qualitative information provides an opportunity to gain a greater insight into 'the why' behind specific behaviour or characteristics associated with the research audience, with the data being 'rich' in detail. This qualitative information will be used to interpret quantitative results, leading to an enhanced and practical understanding of adoptive behaviour. This research approach is expected to provide a sound basis for developing innovative approaches for enhancing technology adoption by the grain growers.

## Chapter Five

### **A FOCUS GROUP APPROACH TO UNDERSTANDING AGRICULTURAL KNOWLEDGE SYSTEMS AND FARMER DECISION-MAKING**

The study to date has developed important concepts and understandings in behavioural change and adoption, largely based upon the presentation of quantitative data. Information presented in Chapter 4 provided a comprehensive description of the relationships between personal and situational characteristics and adoption behaviour. In order to build upon this, qualitative information has been collected to assist in explaining the reasons why some information sources are perceived to be more credible than others, as well as information relating to the social context in which adoption decisions are made. Such information can not be readily collected utilising quantitative research tools, hence the use of qualitative approaches such as those employed through focus group studies can be beneficial. Quantitative analysis presented in Chapter 4 indicated that the decision-making processes that lead to adoption are complex and require further investigation in order to develop a better understanding of why certain behaviours arise. It is these factors that are explored in this chapter, in order to bring about a greater meaning to the quantitative information presented in Chapter 4.

The outcomes from 26 focus group workshops conducted across the agricultural districts of South Australia are presented in this chapter. The workshops were designed to allow participants to provide feedback from the survey, provide assistance in gathering qualitative information relating to the characteristics of local agricultural knowledge systems, and document decision-making processes that farmers undertake when considering adoption of practices.

## 5.1 RESEARCH METHODOLOGY

In all, twenty-six workshops were conducted across the grain growing districts of South Australia between July 17<sup>th</sup> 1998 and November 10<sup>th</sup> 1998. An invitation was prepared and distributed to potential farmer groups (refer to Appendix C), targeting local Agricultural Bureau and crop monitoring groups. Participants at the workshops were farm business managers involved in grain and livestock farming. A total of 257 farmers attended the workshops, of those 249 were male and 8 were female. Workshop participants were in general aged in the 40 to 55 year range. Workshops were held in local community halls or hotels with each session lasted for between 2.5 and 3 hours.

As part of the introduction to the workshop, selected results from the survey questionnaire were presented to participants on a district and regional basis utilising GIS mapping techniques. Participants were then able to benchmark their own farming practices and adoption characteristics with others in the focus group and region. Group sessions were then opened up for comments and interpretation of data. This process helped to obtain valuable information for use in this study, in terms of crop performance and the adoption of specific farming practices. Farmers were asked to identify how they would achieve future crop yield increases, in addition to identifying specific barriers to yield improvement.

In order to gain further information on the decision-making processes that lead to the adoption of innovations, a series of six case studies were presented at the focus group workshops. At each workshop only two of the six case studies were presented and discussed (with the case studies being rotated between the different workshop sessions).

Case study themes related to the following;

1. Selecting a herbicide product for weed control
2. The influence of the agricultural knowledge system on the adoption of no-till systems
3. Decision-making characteristics associated with crop sowing operations
4. Characteristics associated with local agricultural knowledge systems
5. Community pressure and adoption
6. Relationships between adoption and risk management

The case studies addressed specific issues identified through the survey questionnaires that were considered to influence the adoption process. In conducting the focus group discussions a common set of questions relating to each case study formed the basis of group discussion. The workshops were facilitated in a manner that provided all participants the opportunity to contribute to group discussion. This helped to ensure that the views, experience and ideas were obtained from all participants, as opposed to gaining just a few from potentially dominating personalities. Information, comments and feedback were recorded in note form, with clarification of discussion points taking place regularly throughout the workshops in order to ensure the views expressed were representative of the group participants. This information was summarised, with the key themes and outcomes prepared as a summary for each of the case study examples, and are presented in the following text.

## **5.2 RESULTS**

### **5.2.1 Case Study 1: Selecting a herbicide product for weed control**

Group discussions focusing on *“from where do farmers obtain information relating to the selection of a new herbicide product for weed control”* provided an insight into the characteristics associated with information providers in the plant protection (farm chemical) industry. From the workshops it was evident that farmers gather information from a wide range of sources, with the local agribusiness

chemical reseller playing a significant role in the provision of information to the farmer. The local reseller was considered by many respondents to be readily accessible, forming an important link in local information networks. Workshop participants also identified several disadvantages with such information sources, including variability in the quality of information provided, staff with limited field experience, the failure to provide advice and recommendations within a farming systems context, and tendency to sometimes recommend more expensive herbicide products. Sourcing information from the local chemical reseller was associated with a number of distinct benefits, these including ready access to field demonstrations, access to chemical company manufacturers and locally derived knowledge.

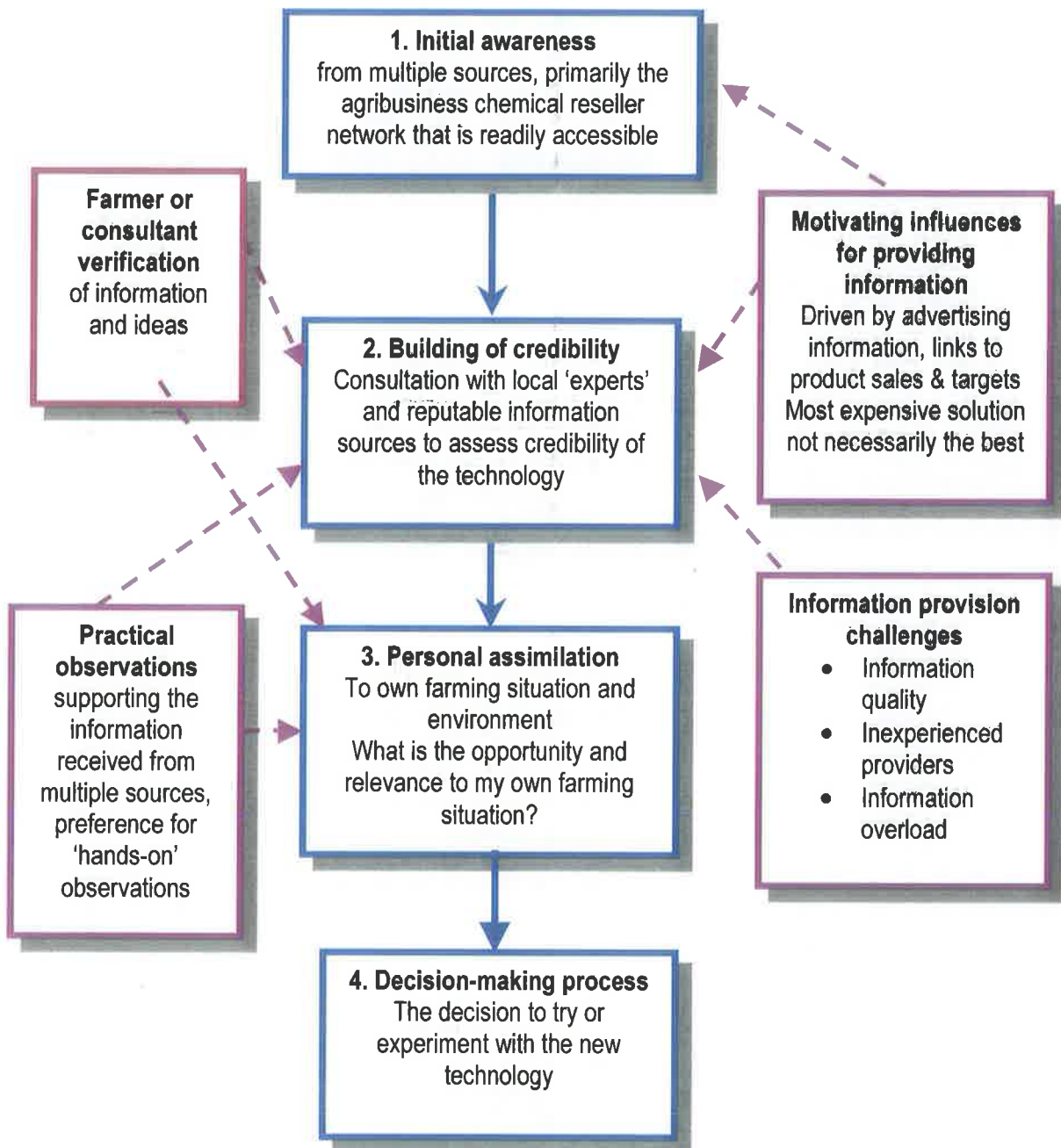
In many situations farmers considered that they were inundated by information, much of it in the form of advertising material. Information on new products, as well as trial results were frequently accessed through the weekly rural farming paper the Stock Journal by most participants. Farmers were aware that such information was often produced as a marketing exercise, and may have lacked credibility and independence. Once farmers had become aware of a particular new herbicide product, they then set about building the credibility of information they received through seeking additional information from other locally generated expertise.

It was recognised by farmers that some reseller groups develop particular alliances with chemical companies. In some instances, it was reported that a certain product was recommended at the expense of another more suitable product. The motivation (from the reseller's perspective) may be higher profit margins associated with alternately recommended products, or lack of supply of the more appropriate product (due to shortage of stocks, or exclusivity in marketing and supply with an opposition reseller network). One workshop participant summarised the net effect of all of this; *"if they push a certain product line, their credibility is shot to pieces"*

It was considered by workshop participants that credible information providers were skilled at introducing new herbicide products into local farming conditions. Often this involved trial and error processes involving adaptability of products and rates to local farming conditions. It is evident that farmers look to the experience of locally based advisers, be they from private enterprise or government. The credibility associated with an individual adviser was considered to develop over a period of time as they gained local knowledge and experience. Farmers were of the opinion that this does not occur instantaneously, but over an extended period of time.

Feedback from workshop participants indicated that often there was too much weed control information available, leading to overload. Depending upon the perceived credibility of the information source, farmers often looked to more credible sources (including other farmers) to verify the information that they had obtained from other less reliable sources. Where possible, farmers considered it essential to observe the results for themselves out in the paddock. Based on the information received from the workshops, the factors that characterise the decision making process associated with the selection of an herbicide product for weed control are summarised in Figure 5.1.

**FIGURE 5.1 Summary of the decision-making process associated with the selection of an herbicide product for weed control**



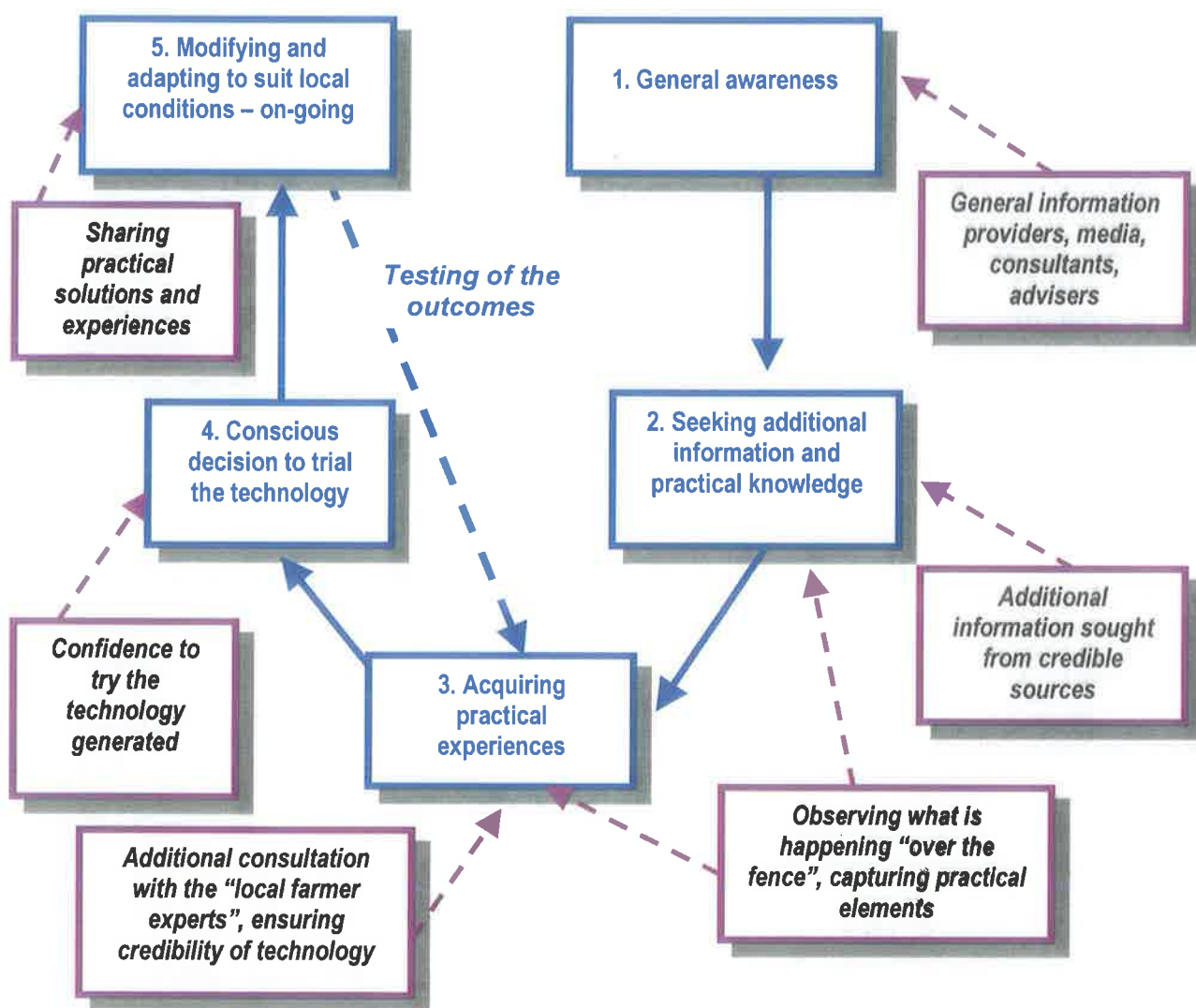
### **5.2.2 Case Study 2: The influence of the agricultural knowledge system in relation to adoption of no-till seeding systems**

Workshop participants were asked to describe the characteristics associated with information sources linked to no-till seeding systems. Participants stressed the need to provide information in a practical and local context. Examining what was "happening over the fence" was particularly important in order to capture the practical elements of developing and adapting the new technology. In many instances workshop participants mentioned that they often consulted the local farmer expert, who tended to be innovative in the development and adaptation of new technologies. For many this provided elements of inspiration and confidence to begin experimenting with the new technologies.

It is evident that in the case of a complex technology such as no-till, farmers look towards practical solutions and experience, particularly from other farmers who have through trial and error adapted such systems to suit local farming conditions. Whilst advisers and consultants provided general awareness information, it is evident that in the case of no-till farming systems farmers look to the experiences and knowledge from other farmers when developing such a system for their own farm. According to many workshop participants, the adoption of no-till farming systems takes place over an extended period of time through a process of trial and error. Many considered it to be a step-by-step process (as summarised in Figure 5.2);

1. First becoming aware of the technique
2. Seeking information from others
3. Looking to the experiences of other farmers
4. Consciously making a decision to try the new technology
5. Modifications of specific seeding systems techniques in order to adapt to local cropping conditions and needs (often through 'trial and error')

**FIGURE 5.2** The influence of the agricultural knowledge system in relation to adoption of no-till seeding systems



### 5.2.3 Case Study 3: Decision-making characteristics associated with crop sowing operations

How farmers manage risk at seeding time was the third of the workshop case studies discussed. The aim of the exercise was to try and identify the steps that farmers go through when developing a strategy for sowing of crops. Farmers in low rainfall environments were targeted for this case study; where the decision to sow was seen to be more complex and uncertain as a strategy to better manage risk. This was because of the fact that often the farmers in marginal rainfall districts are faced with the difficult decisions (and risks) associated with crop sowing operations.

Participants felt that the risks associated with early sowing could be reduced by spreading the risk of sowing over a wider sowing window. For many it was viewed as a constant trade-off between frost risk and yield penalties due to later sowing. It was considered a case of constantly reviewing and reassessing sowing strategies. Early sowing and the risk of frost were considered to be of a major concern to most groups involved in the workshop case study. Many considered frost risk could be minimised by sowing the high ground first, followed by sowing lower lying, frost prone ground last (where later sowing would assist in a later maturity (flowering) of the crop beyond the period of frost occurrence). The sowing of crops over an extended period of time was viewed as one means of better managing frost risk. Consideration to the wind erosion potential caused through late sowing was also a necessary factor that needed to be considered. The next impediment to early sowing was identified as being marginal soil moisture conditions at sowing (leading to the risk of poor germination).

Developing a plan or strategy identifying what crop types and paddocks would be sown, and in what order was a worthwhile strategy for minimizing risk when it came to sowing. Learning from mistakes and other personal failures were viewed as being a hard way to learn, but made greatest impact on changing practice. Keeping an eye on the neighbour was likewise an important factor in practice change, according to many of the workshop participants.

Workshop participants considered that they were under pressure if their neighbours were busy carrying out tillage and seeding operations – when they themselves were not carrying out any paddock work, even if they had previously considered conditions were not favourable for seeding. This is a particular issue in relation to those farmers who were in the process of adopting no-till farming systems, where due to the elimination of tillage operations, farmers generally have to wait for a germination of weeds prior to controlling them chemically. Subsequently, there was no need for visible tillage operations straight after

a significant rain, compared with conventionally prepared crop sowing operations. None the less, the social pressures of "doing nothing" were still considered to be significant for many workshop participants.

Under marginal soil moisture conditions, the decision to stop the seeding operation half way through the program was considered a difficult decision to make. Often the question arose as to "*is there enough moisture to achieve satisfactory germination?*". It was considered that marginal soil conditions often resulted in a patchy germination of seed. Weather reports provided by the Bureau of Meteorology would sometimes influence the decision to proceed with seeding, however the final decision to start seeding partly relied upon gut feel that was re-enforced through experience.

Participants considered that any decision required constant monitoring, whilst the need to observe others was seen as an important part of this process. Listening to other farmers on the UHF radio, identifying "*who was doing what*" and trying to establish "*why are they are doing it*" were questions that participants needed to be answered. The UHF radio provided a neighbourhood broadcast mechanism, in terms of identifying what others farmers were up to across the district. It was considered to act as a vital listening post, as an indicator of paddock activities.

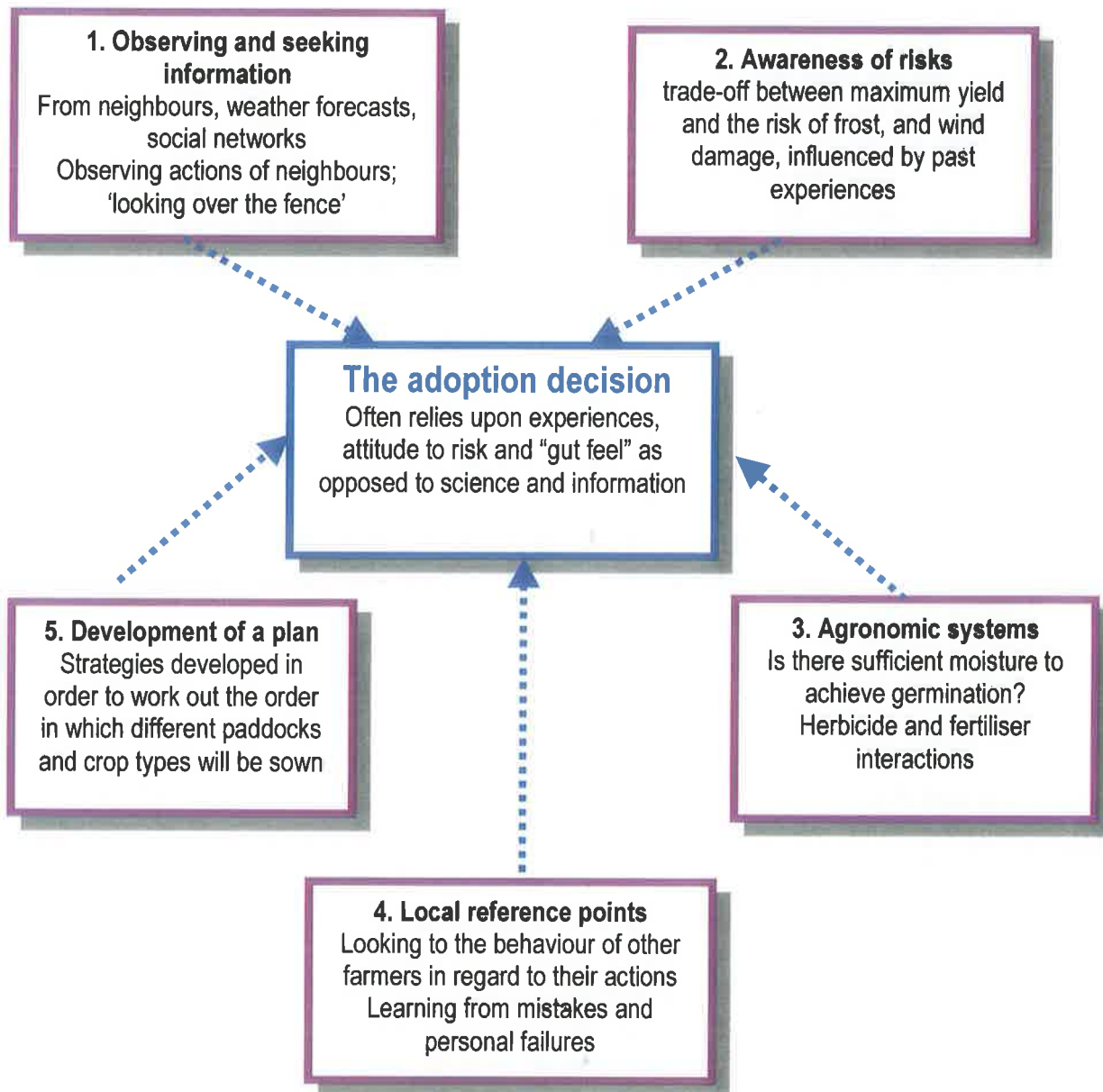
Information was also gathered from a range of social environments, such as the hotel, sporting events such as football and other community based social events. Certain farmers within the community were used as reference points, in terms of whether seeding should be carried out or not. From this, it is evident that informal communication networks form a valuable role in the exchange of information, ideas and experiences, thus playing a significant role in the overall decision making processes of farmers involved in this study.

In summary, considerations farmers make towards crop sowing decisions are summarised as follows;

- How critical is the timing to sow the crop (timing of the sowing operation, likely outcomes in terms of potential yield losses due to delayed seeding versus potential for frost risk)?
- Information gathering: What are my neighbours doing? What are my own past experiences and strategies?
- Seeding conditions: What are the seed bed conditions like? Will I achieve a satisfactory germination if I sow now? Have I strategies in place to manage plant disease, germinating weeds?
- What order will I sow the crops in (consideration to topography, crop requirements, varietal maturity, susceptibility to frost)?
- Monitoring of the seeding operations, crop emergence. Do I continue, or delay further seeding activities?

It is evident that there are many factors that are taken into consideration when farmers contemplate their crop sowing operations. Issues relating to what other farmers are doing, past experience and the individual management of risk are major considerations that influence farmer decision-making. The relationships between those factors that influence farmer decision-making in relation to the management of risk at crop seeding time are presented in Figure 5.3

**FIGURE 5.3** A summary of key decision-making characteristics associated with crop sowing operations



**5.2.4 Case Study 4: Characteristics associated with local agricultural knowledge systems**

Workshop participants were asked to describe characteristics associated with their local agricultural knowledge system, in terms of information sources and networks, the most influential information sources, and the characteristics associated with credible information providers.

It was generally considered by participants that farmers now had far greater access to information from a much wider range of information sources than 15 or more years ago. Traditionally the local Agricultural Bureau was viewed as the principal source of information. It was felt that nowadays there were more information providers. Farmers were found to be travelling more widely for information, resulting in higher levels of information exchange and transfer both within and external to local agricultural knowledge systems. It was considered that social conversation provided opportunity to discuss and compare with other individuals farm decisions and practices. It is evident that farmers valued open discussions with one another and developing networks in which they could share this information. Some workshop participants described this as a form of peer review or mentoring, allowing them to develop the best strategies for their crop management activities.

Farmers generally look for information through practical means, by talking to experienced and credible advisers. Farmers also valued the information that they gained from trials and demonstrations. Participants considered that information provided in a printed form acted as an awareness mechanism of the general features and benefits of a new technology or cropping input product. Access to this information was usually followed by more active seeking of further information from other reputable sources.

Group discussions also focused on the level of credibility associated with information providers. In general farmers felt that a person's credibility developed over a period of time, as the experience of the individual built up. One workshop group believed that as a client, *"you need to get used to the personality of the agronomist - it takes a few years in order to get that trust"*. Workshop participants considered that the credibility associated with a person was reflected through their ability to have a sound knowledge of the local area and an ability to identify the needs of the person they were dealing with. Other important attributes also included sound communication skills and the ability to listen. This

development of credibility in the information provider was considered to develop over a period of time. Participants valued the ability to access independent advice. Many participants were of the opinion that if the results of the technology were observable, information would then be viewed as being more credible.

Workshop participants found that it was difficult to define a single influential source that provided them with the impetus to try a new innovation such as no till. They considered that information came from multiple sources over a period of time, rather than placing dependency on the one information source. In most instances it was felt that information was best delivered in a practical context, taking into account local farming conditions and systems.

Agricultural consultants were viewed as being a valuable information source. Farmers found that a locally based consultant would always be one of the first to hear about a new product, particularly if they were involved in trial work dealing with the new herbicide products. Consultants provided the advantage of acting as a filtering mechanism for identifying information most applicable and relevant to local farming systems. The ability to see the results in the paddock, on soil types / conditions that reflect local farming conditions were considered essential if adoption of a product or practice were to take place.

It was considered important to monitor the farming operations of other farmers during seeding operations. In many situations farmers preferred to seek information from those whom they could relate to, as opposed to accessing ideas and information from the highly innovative farmers (who were always the first to try new technologies, and tended to take greater risks). Social conversation provided the opportunity to compare with others individual farm decisions and practices undertaken. It is evident that farmers value open discussions with one another and developing a network in which they can openly

discuss and share information. Discussions were considered a form of peer review, in terms of identifying recommended cropping operations and strategies.

The informal discussions at the local hotel provided a great opportunity for exchanging ideas and information in a less threatening environment. Farmers who didn't openly discuss information were almost looked down upon, in terms of identifying what their hidden agenda was, and questioning as to why didn't they share their experiences with other farmers in the local community. A philosophy of information sharing for the betterment of the community and industry was a general ethos shared by many of the farmers in the district. For those farmers who did not share their experiences, farming operations would be closely scrutinised. Some farmers even went to great lengths to jump the fence and check out seeding depth and plant establishment numbers of those farmers who were unwilling to contribute to the community information sharing process.

#### **5.2.5 Case study 5: Community pressure and adoption**

The influence of community pressure relating to farmer decision-making was explored as a topic of discussion amongst workshop participants. The focus of discussion centred on the notion that there were strong elements of social pressure within local communities associated with the adoption of socially desirable farming practices. The dynamics of information exchange was also explored, as an element of local agricultural knowledge systems.

Some workshop participants felt that community pressure in relation to the adoption of farming practices tended to increase with age. The fear of worrying about being a failure was considered to be a reflection of community pressures, in terms of how people are judged and perceived in the local community. Many workshop participants felt that there was almost a form of community benchmarking, commenting that it was often considered important to look over the fence and see the new practice in operation, comparing

new and traditional farming practices. Workshop participants felt that change to a certain extent was influenced by the need to conform to community norms, or at least follow what the neighbours were doing. An important comment related to the fact that there were plenty of failures with those existing farming practices that were considered to be acceptable farming practices however often these went unnoticed. Failures associated with the adoption of new farming practices were considered to receive far greater attention.

Some groups identified those farmers who had not changed within their community as being low input farmers. Whilst workshop participants were not directly critical of their practices, many considered that it was always a worthwhile exercise to compare new farming systems with the old. Low input farmers were viewed as not being under any pressure to change, since many were regarded as living cheaply and did not have high input costs. It is evident that there was great variability in the level of production between farmers within a given district, particularly when comparing traditional with the latest innovative approaches to crop production. Such farmers who had relied on a traditional farming system were considered to provide a benchmark for comparison with those farmers who were in the process of adopting new technology. It was also evident that not all farmers are driven by the need to maximise productivity or profitability.

Farmers valued the experiences and opinions of neighbours, and considered them an important source of information within local communication networks. Attitudes were now more positive towards the adoption of new farming practices, with a shift from elements of conservatism over the past 20 or more years. This was reflected in the following quote from one of the focus group workshops;

*"As young farmers out of school, we were told to watch someone conservative, some old farmer over the hill, who tended to under stock, and who only cropped a quarter of his land. We now place an emphasis on measurement (be it crops or*

*wool measurement), and look towards pace setters like farmer x. Previously trend setters were laughed at, and now we are following them."*

Workshop participants also commented on a gradual reduction of farmers in the district. Many farmers had left farming over the last few years. It was felt that those farmers remaining were in a position to make changes and take on new technologies, often this was considered necessary in order to remain economically viable.

#### **5.2.6 Case Study 6: Relationships between adoption and risk management**

The relationships between the adoption of technologies, and the influence of risk management were explored as part of a case study approach with the focus groups. Workshop participants were of the opinion that many of the decisions made on farm tended to be complex in nature, due to the degree of relationships between variables and the farm business system. It is evident that participants believed that the level of adoption was influenced by attitude to risk and whether farmers were comfortable appearing to 'go out on a limb' with adoption (relating back to community pressures).

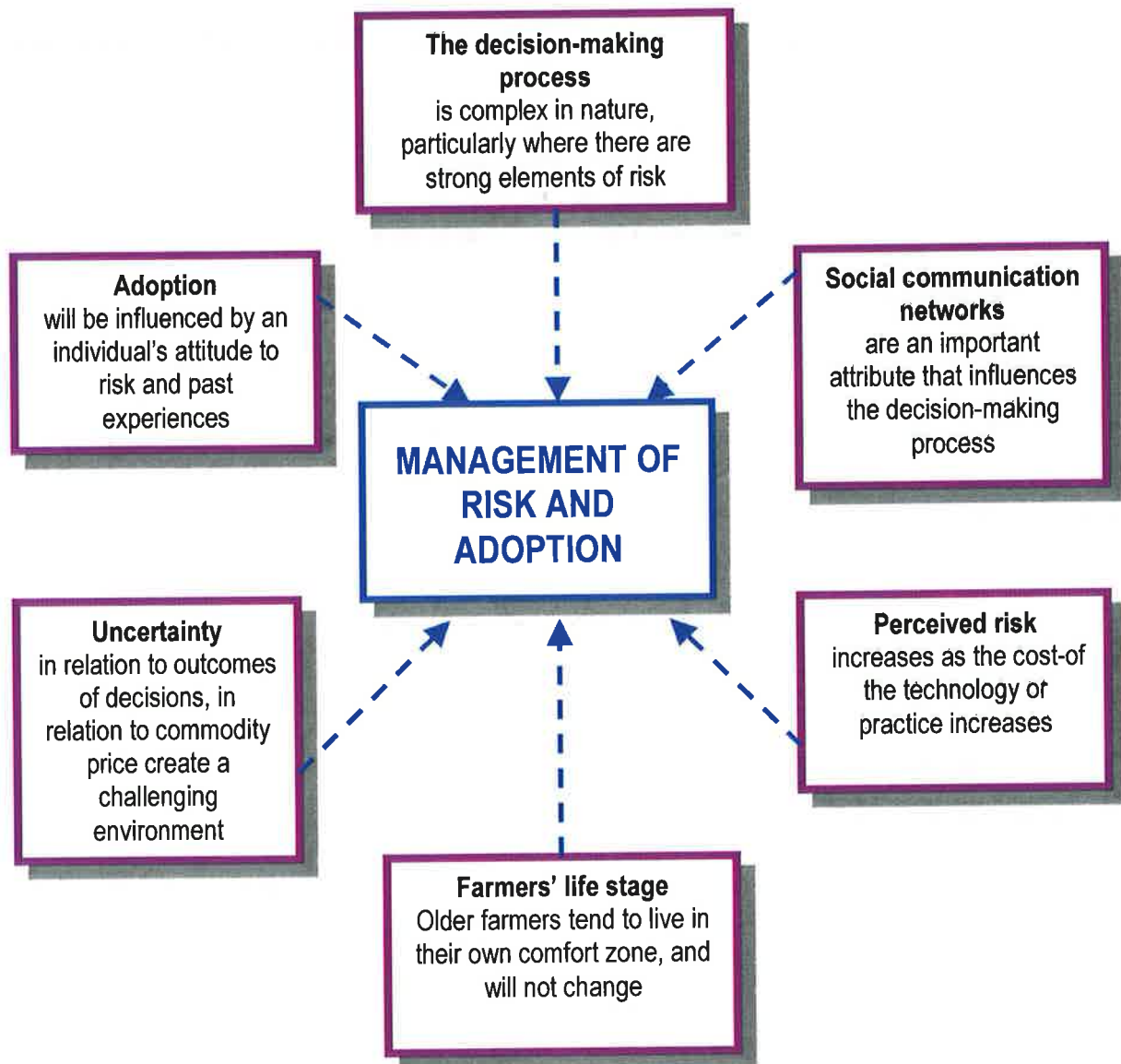
Some workshop participants believed that many of the older farmers in their district live in a comfort zone of their own, *"they don't necessarily have to look after the land, they complain about not being able to get the pension, but have too many assets"*, is one comment from a workshop participant. Participants believed that often there was a perception amongst older farmers that they did not have the capacity to pay off farm debts, hence there was a very high degree of farming conservatism practiced. Participants felt that one of the main barriers to the uptake of new technology was farm size. As a result technology was adopted in a piece meal fashion, due to the high costs of new technologies.

The adoption of new technologies led to a need of "*relearning your job as a farmer*" according to one group of workshop participants. It was considered that more and more farmers were now becoming aware of the potential problems associated with soils, drought and floods. As a result it was felt that there was community pressure to conform to such technologies such as minimum tillage. Workshop participants were often concerned that productivity improvements were viewed in isolation. Many considered that it is essential to consider the risks associated with aiming for higher yield and the costs. Just as important was the uncertainty to forecast grain prices (at harvest), making pre-seeding decisions a difficult task for many.

Participants from low rainfall farming districts felt that many technologies had been developed in the more reliable rainfall districts. Attempts at modifying the technology for the lower rainfall districts have been made on a local basis with mixed success. It was considered that risk management played an important role in the willingness to try the new technology. Several groups questioned the appropriateness of Intensive cropping systems in marginal cropping districts. Higher input costs associated with summer weed control, spray topping and use of knockdown herbicides introduced a higher element of financial input and risk.

The willingness to adopt new technologies through developing appropriate risk management strategies may be influenced by the anticipated pay-offs associated with the technology. Relative productivity associated with the profitability (and the relative ease of achieving this) will influence the management of risk in the farming operation. It was generally considered by workshop participants that if there was a perceived high reward associated with the adoption of the technology (in a relatively risk free environment), then it was more to be adopted. These relationships are presented in Figure 5.4.

**FIGURE 5.4: A summary of factors that influence the management of risk and adoption of practices as summarised from focus group studies**



### 5.2.7 Capturing the qualitative information from the survey questionnaire

There were many issues also raised by respondents to the Cropping 2000 survey questionnaire relating to the adoption of new technologies by other farmers within local agricultural knowledge systems. Many of these comments complement and support the findings from the focus group discussions, and are presented in the following text.

Many farmers found it difficult to identify exactly what information is of relevance to them. Information was considered to be in over supply, making it difficult to determine relevance to their own local farming environments. The following provides an overview of some of the comments from survey participants that support this observation;

*"We live in an environment surrounded by ideas and information. The issue is to sort the wheat from the chaff, to identify what you need and want, to do that well. My guess is that most farmers, knowingly or subconsciously, do just that".*

*"There appears to be an information oversupply. We are growing grain on the driest continent on earth, climatic factors are paramount. Management decisions can change radically. We are told higher inputs are the most successful but most survive by being conservative."*

*"There seems to me to be an information overload with reading, TV, radio, bureau ag. groups and seminars by the dozen."*

*"There is a vested interest in information...explosion in number of resellers, middlemen etc. We gather our own info, and take vested info with a grain of salt. Too many "operators" don't. Why share our good methods with people who bid against you at the next land sale?"*

*"Farmers need advice without vested interests."*

*"Too many people (so called gurus) tell us how to go about our business, who have never been hands on farming. The best source is from people who have done it and succeeded."*

*"Many farmers are becoming confused with the high levels of information that is current..... Information needs to be packaged that is relevant for their district."*

*"Farmers should be able to make their own decisions by observations...and not pay for some smart businessman who has not had farming experience – they only learn from other farmers ...trial and error is a good teacher".*

The following comments provide an illustration that for many farmers they are farming within a context of the environment of many years ago. It is almost as if they have been caught within this by-gone period, and are reluctant to accept the fact that they are now farming in a changed social and political environment;

*"A bit hard to fill out (the survey questionnaire) because of a stubborn old man who won't change farming practices and a stubborn owner of land I share farm who won't spend money to improve his land. So my hands are tied."*

*"I have grown my 60<sup>th</sup> crop since leaving school at 13 years of age. I think the best time of my career was during the years 1949-1960 when rust was overcome in cereal crops. DDT cured blowfly and lice problems in the sheep flocks and most importantly Mixomatosis (sic) wiped out the rabbit problem."*

*"I finished my primary schooling in 1930 just before my 13<sup>th</sup> birthday. As the eldest son of a large family I had to immediately replace a big strong Italian labourer. Because of the depression, and with my father still having a number of sons still at school, he acquired a number of cheap farms so that his boys would not be unemployed. When the war broke out in 1939 I obtained exemption because I was a shearer and was expected to do 4 months shearing and 12 months work on the farm in 8 months....what I learnt from my fathers big enterprise was that it was unmanageable....this year I completed my 53<sup>rd</sup> seeding and hopefully will harvest it with the potential to yield 1.4 to 1.8 t/ha."*

*"We have had a very hard battle over the years, mainly because of the high interest rates in the late 80's. Our production has almost doubled, but with expenses so high we don't make much headway. It's OK for those who never had to buy their farms – they can afford to make a few wrong decisions."*

### **5.3 DISCUSSION**

The focus group workshops have assisted in providing qualitative information that has helped to interpret characteristics associated with agricultural knowledge systems and decision-making processes that lead to farmer adoption. As a result, this has helped to provide a depth of qualitative information that would have otherwise not been obtained as part of the formal survey questionnaire as presented in Chapter 4. There are a number of specific underlying themes emerging from the workshops that assist in building an understanding of the agricultural knowledge system and farmer decision-making processes. These relate to the credibility of information providers and information delivery, the social pressures associated with adoption and change in rural communities, decision-making processes leading to adoption and the management of risk within an agricultural knowledge system.

### **5.3.1 Credibility in regard to information provision**

The focus group workshops were successful in identifying the characteristics of the agricultural knowledge system, with one of the most important elements discussed relating to the credibility associated with information providers, and the nature of the delivery environment. The workshops assisted in identifying how information delivery could be better targeted and tailored to the needs of the farming population. Characteristics of information that include relevance, independence, practical in nature, and delivery by an experienced person were considered to be critical elements associated with the delivery of sought after information. These findings are supported by the earlier research of Bell (1998), Kilpatrick (1999) and Guerin and Guerin (1994).

Workshop participants were sometimes reluctant to utilise information sources provided by agribusiness reseller groups, because of perceived links between the provision of recommendations and the financial rewards derived through the marketing of agricultural chemicals. Information from agribusiness reseller groups however tended to be more freely available, also identified by Alston and Reding (1998). It is also evident from other research that the private agribusiness sector is playing an increasing role in information dissemination, with farmers shifting to agribusiness for their information needs (Schmitt et al. 2000). This is evident where there is a commercial gain to be made from the specific technology, where commercial agribusiness input suppliers have had major influences in relation to the adoption of variable rate technology and precision agriculture (McBride and Daberkow 2003).

Farmers from the focus group workshops tended to value most independent advice provided through government extension officers and agricultural consultants, with similar findings being obtained by King (1995) in his study of preferred information providers for farmers. It is evident that the practical orientation of both farmers and consultants are critical to the dissemination of information within agricultural knowledge systems, with this observation supported by Coughenhour and Chamala (2001)

and Schnitkey et al. (1992). Farmers value information originating from other farmers highly, viewing such sources with high elements of credibility (Radhakrishna 2002, Rowan et al. 1994).

Within local knowledge systems there are a wide range of information sources that farmers utilise on both a formal and informal basis. The characteristics of credible information providers have been well defined, as has the context in which information is best transferred to farmers. It is evident that farmers prefer independent and credible information sources. According to Guerin (2001) in order to achieve adoption amongst farmers their advisers must have empathy, an understanding of the context in which farmers operate and have credibility amongst the farmers concerned. These findings are supported by Kilpatrick and Rosenblatt (1998), who found that farmers prefer to be active seekers of information and be in a position to make their own decisions as opposed to being told what to do.

### **5.3.2 The social pressures associated with adoption and change**

From the workshops, it is evident that there are community pressures evident in relation to the adoption of new technologies, with often the conservative types of farmers being viewed as benchmarks by the more progressive farmers whom are aiming to improve their farming systems. The motivation to change is not only determined by social pressures, but also the need to maximise profit, however in some instances personal goals can cause conflict within a social environment (Wallace and Moss 2002). It is apparent that farmers compare themselves with one another, through an informal "benchmarking analysis". Social communication networks, many of which are extremely informal in nature play a significant role in influencing the management practices conducted on-farm.

### **5.3.3 Decision-making leading to adoption**

It is evident from the studies that the process leading to the decision to adopt a new technology occurs in a step-wise manner (refer to figure 5.2, relating to the adoption of no-till seeding systems). This

observation is supported by the work of Dimara and Skuruas (2003), who considered that adoption was not a one-step process of either acceptance or rejection of an innovation, but characterised by a series of multi-staged decision-making processes. The adoption of no-till systems amongst workshop participants was often hampered by the cost and availability of machinery, a common factor identified by D'Emden and Llewellyn (2003) and Kingwell (1996).

#### **5.3.4 Managing risk within an agricultural knowledge system**

From the workshops, it is evident that farmers develop a risk management framework subconsciously, as part of their overall approach to farming. Past experiences are considered to play a major role in assessing the suitability of a new farming practice or system. The capacity of individual farmers to do this will be determined by their own personal and situational characteristics, with some groups in the study more likely to adopt new practices successfully than others. It is the attitude to risk that is considered to be the main influencing factor in relation to adoption behaviour, described by Guerin and Guerin (1994) as part of a risk avoidance attitude held by conservatively orientated farmers. Studies conducted by Ghadim et al. (2005) concluded that the decision to adopt was influenced by two main risk-related factors; 'risk aversion' and the relative 'riskiness' associated with the particular innovation.

#### **5.3.5 Farmer typologies – descriptions of the clusters**

In Chapter four, the k-means cluster analysis identified 10 clusters of farmers, based on an analysis of personal and situational characteristics. The question arises as to whether or not such clusters can be easily identified within the knowledge systems studies as part of the focus group workshops. Whilst there were no direct references made to cluster descriptions in the workshops, there was similarity between some farmer profiles as described by workshop participants and those derived from the k-means cluster analysis.

From the studies it is evident that farmers openly compare themselves with others across the district, with a strong fear of failure being a common community pressure. The process of comparing and assimilating is in effect a form of assignment of typologies to different types of farmers within the local social network, building on the market segmentation approach that was presented in Chapter four. In this instance, these observations would compare closely with either of the following two clusters;

Cluster 1 "Quit now"; extremely low equity, very low innovativeness, minimal access to information, low adoption of practices, low education, not greatly concerned in relation to business viability.

Cluster 6 "Retirees"; very low adoption of best management practices, very low level of innovativeness, very low access to information, very low education, below average wheat yields, slightly above average business equity, high farming experience, smaller land size.

Whilst the focus group workshops did not discuss or identify the applicability of such farmer typologies, it is an area of research that would certainly be worth exploring in the future in order to determine the validity of such an analysis and interpretation. Within some rural communities it was felt that farmers had a responsibility to share information with other farmers. The workshops found that farmers compare themselves with one another, a form of social benchmarking. Farmers that are more progressive compare themselves with traditional farmers, who have either not changed or who are near retirement.

#### **5.4 SUMMARY**

Outcomes from the focus group workshops helped to build the thesis, through provision of qualitative information that has allowed the probing and testing of research questions and specific understanding arising from the analysis. This process assisted in the clarification and interpretation of results within the context of localised farming systems. It also provided the opportunity to obtain additional local knowledge that would not otherwise be obtained from the formal survey techniques used in this study.

Often innovative farmers use the traditional farming operations of non-adopters as a local benchmark for comparison with emerging farming systems. Social networks and participation in a range of education and training activities have been associated with those groups of farmers who were more likely to have higher levels of adoption, productivity, and profitability. The levels of access to information sources were considered to be strongly linked to higher rates of adoption.

Information provided to farmers will only be accepted if it is from a credible source. The acceptance of information is likewise linked to the environment of delivery (situational characteristics), as well as the personal characteristics (including the behaviour) of the farmer. Local information networks were influential in terms of creating awareness of farming practices and technologies. Community and peer pressure were considered to influence the adoption processes of new farming practices.

The focus group workshops provided the opportunity to discuss and examine *who it is* that provides information in the local community. The results and discussion presented has been successful in terms of providing the opportunity to build upon the outcomes from the survey questionnaire as described in Chapter four. The qualitative information presented has successfully described the issues and barriers associated with decision-making and adoption. Information has focused on decision-making and the management of risk, as well as the characteristics of local knowledge systems and communication networks existing amongst farming communities.

It is evident that the decision-making environment associated with the adoption process is complicated, with a whole range of social pressures and influences. The focus group studies clearly demonstrated the benefits of gathering qualitative information that has helped to develop greater meaning of the socio-economic characteristics of farmers and how they influence adoptive behaviour.

Chapter six (the final chapter) will address the research questions posed at the outset and the hypothesis tested will be formally addressed. A summary of the key outcomes arising from this research study and recommendations for future research will be provided.

## Chapter Six

### GENERAL DISCUSSION

The purpose of this chapter is to present an overview of the key outcomes arising from this study, including contribution to new knowledge. This chapter will address the research aims, questions and the hypothesis in a holistic manner and present the key findings. Recommendations and conclusions as to how extension agencies may best introduce new extension models aimed at achieving change at the farm level will be presented, in an effort to put into practice new knowledge and understanding generated through this study.

The conclusions from this research study are provided with a high degree of confidence, reflected through the large population size and favourable response rate achieved from the survey questionnaire (2472 responses from a total population of 4,470 farm businesses, representing a 55.3% response rate). As a result, it is with a high degree of confidence that the findings from this study are applicable to grain growers across South Australia and similarly Australia. It is also likely that outcomes are applicable to farmers in other parts of the world who operate under similar business constraints and social environments.

#### **6.1 OUTCOMES FROM THIS STUDY**

Responses to the research questions posed in this study are presented in this section, followed by a formal response to the hypothesis.

##### **6.1.1 Market segmentation approach to describing farmer typologies and adoptive behaviour**

This study successfully developed a market segmentation tool for describing farmers, on the basis of socio-economic characteristics and adoptive behaviour. From the multivariate analysis undertaken,

PCA and k-means cluster analysis identified specific sets of variables known to influence variability in the research audience, leading to the identification of clusters of respondents, each having their own distinct characteristics. This formed the basis of describing farmer typologies, which assisted in identifying those clusters having the capacity and capability to embrace change on-farm. This approach minimised the degree of researcher bias in identifying and describing the typologies associated with each cluster. In doing this the potential risk of describing farmer typologies for the purpose of explanation rather than deriving them through empirical observations was reduced, a common issue in relation to many studies that focus on the identification of farmer typologies (Vanclay et al. 2006),

The application of farmer typologies provides the opportunity to improve the efficiency of extension programs through generating a far greater understanding of the circumstances in which different farmers operate (Emtage et al. 2006). Outcomes from this study have provided a sound basis for developing clearly targeted programs that are designed to meet the needs of farmers themselves, acknowledging the personal and situational characteristics associated with such farmers. Wilcock et al. (1999) had earlier identified the benefits of such an approach, in terms of identifying the specific needs of each farmer typology identified, and tailoring delivery programs to address the unique characteristics of each grouping.

Based on the identification of farmer typologies through the market segmentation process adopted in this study, it is now possible to specifically target certain segments of the population for any given extension program. This will assist in the delivery of a specific technology, within the context that takes into consideration the characteristics associated with the market segment that is targeted.

### **6.1.2 Influence of socio-economic (personal and situational) characteristics relating to adoption, innovativeness and production capabilities**

This study identified that farmers cannot be categorised solely by their adoptive behaviour as has been the traditional case promoted by researchers such as Rogers (1995). Rogers' use of derogatory names such as 'laggards' has done little to enhance the explanation of the complexities associated with the adoption process, and has instead led to a tendency to stereotype adoptive behaviour amongst those farmers considered to be slow to adopt or reject new technologies (Howden et al. 1998).

This research study has established logical reasons as to why farmers do not readily adopt technologies. The adoption process is influenced by a range of environmental characteristics, including those of the agricultural knowledge system, social pressures associated with adoption, credibility of information provided and the characteristics of the technology itself. The provision of advice to farmers needs to have a social understanding (Vanclay 2004), i.e. address the social drivers of change (Boxelaar and Paine 2005).

Outcomes from this study indicated that the life stage of the farmer combined with their own personal capabilities influenced their ability or desire to introduce change on-farm. Older farmers within a community were often considered by other farmers to operate in a 'by-gone era', and were seen to face difficulty in responding to change. For many it was evident that they had a preference towards conservative and traditional farming practices, with many considering that there was no justifiable reason for introducing change on-farm. The opportunity for extension organisations to influence the behaviour of such farmers is extremely limited. There may be the opportunity to introduce programs that aim to develop succession planning strategies within the farm family business, and identify who within the farm business is likely to embrace change; often likely to be the next generation. In many

instances targeting those farmers who want to change and improve their farming and business systems would be a more efficient use of extension resources.

Adoption amongst the survey population was linked to the environmental characteristics associated with the location of farms, such as growing season rainfall. Survey analysis identified that those farming in high rainfall districts were more likely to have adopted greater number of farming practices in comparison to respondents from marginal rainfall districts, where low rates of adoption had taken place. This trend was most evident in relation to complex farming practices. Farmers operating in low rainfall environments had a strong tendency to opt for low-risk farming practices, avoiding the adoption of relatively complex high-risk practices such as crop establishment systems involving no-till. Simple technologies such as grading seed and monitoring weeds were more readily adopted across all rainfall environments. These observations are supported by other studies that have established strong relationships between the management of risk on-farm and the adoption of technologies by farmers (Samson 2006, Ghadim et al. 2005, Sadras et al. 2003, Cary et al. 2001).

On the basis of quartile comparisons (top 25% versus bottom 25%) of variables relating to adoption, innovativeness and production capacity, the study has been successful in identifying significant differences in the population. Quartile comparisons highlight the differences in the capacities and capabilities of farmers within the survey population, and are indicative of the potential gains that are possible through increased efficiencies and productivity gains (i.e. moving the bottom 25% of farmers towards the top 25%). Similar differences between the quartiles are also reflected in the different attitudes to risk and uncertainty. Conservative behaviour by some of the farmer groups could result in an opportunity cost through loss in production potential, particularly in favourable cropping seasons (Sadras et al. 2003).

### **6.1.3 The nature of the agricultural knowledge system, technology characteristics and influence over adoption**

Outcomes from this study indicated that the adoption of farming practices was influenced by the characteristics associated with local agricultural knowledge systems. It was found that the credibility associated with information providers developed over time, with farmers seeking to confirm the authenticity of advice from an independent and experienced secondary source that farmers considered they could trust. Social pressures relating to the need to conform to accepted practices and norms within a farming community were also considered to influence farmer behaviour.

This study identified that farming practices are not adopted in a 'piece meal' fashion, but rather farmers adopt sets of farming practices in sequence; often from a systems management perspective, supporting earlier work of Frank (1994a), and more recent work of Doss (2006), who found that farmers adopt practices in a logical progression, with decision-making processes occurring in an integrated manner. It is important that those with the responsibility of developing extension programs consider adopting a systems approach. In doing this the relationships and impact between practices can be taken into consideration when developing adoption strategies for farmers.

The characteristics of the agricultural knowledge system and those of the technology itself influence the adoption of technologies by farmers. As a result of addressing the research questions, the hypothesis can be accepted; *the adoptive behaviour of farmers is influenced by the nature and complexity of the agricultural knowledge system, and personal and situational characteristics.*

## **6.2 DEVELOPING THE ENVIRONMENT OF CHANGE – SETTING THE PARAMETERS**

This study has created a better understanding of the nature of change amongst Australian farmers engaged in grain production. The opportunity for farmers to enhance their capacity and capability to embrace change, overcome potential barriers to the adoption of improved farming systems and

technologies has been established, and is supported by work conducted by Cary et al. (2001). An appreciation of how these key elements interact will provide the foundations for developing improved systems of change. Such extension approaches need to be sympathetic to the personal and situational characteristics of the farming communities.

### **6.2.1 Market segmentation approaches for efficient resource use**

A market segmentation approach to extension programs will assist in developing change systems that are tailored to the specific characteristics and needs of the specific farmer profile or typology, an approach recommended by Greiner and Lankester (2005). Using market research as a basis, there is the opportunity to develop extension programs that have a sound understanding of farmer motivation for change, as well as their individual needs (Kaine et al. 2005). The needs and requirements of those that are young and enthusiastic wishing to establish themselves in the industry will be different to those farmers approaching retirement or who are in financial trouble. This is reflective of differing life stages of farmers, as well as other personal and situational characteristics.

In agreement with this approach are Darnhofer et al. (2005), who consider the market segmentation approach (based upon the identification of farming styles) to be a preferred option for targeting change amongst specific groupings of farmers. Where significant change in the production capacity of the farmers is the goal, it will be possible to target farmers that have the capacity and capability to change. For other farmers, the priority may be succession planning for retirement, or alternatively up-skilling them to enhance their productivity and profitability.

In order to target such a population an appropriate strategy would be to identify the general characteristics of the population concerning the way they seek information and develop mechanisms to influence and change behaviour. Specific examples are illustrated through the work by Boehlje et al. (2004), who found that agribusiness companies attempted to develop a better understanding of

their customer (farmer) needs through market segmentation approaches. As an outcome of this approach, marketing strategies were developed to respond to the buying behaviour of farmers and characteristics relating to farm size, cropping practices and the management of risk and technology. Similarly Maybery et al. (2005) suggest that farmers should be viewed as customers having unique characteristics who can respond to appropriate stimulus for change.

### **6.2.2 Identifying personal capability and capacity for change on-farm**

This study was successful in terms of identifying specific clusters or typologies within the target population and developing understanding in relation to their behavioural characteristics. The study identified the important elements of farmer capacity and capability required to successfully introduce new farming technologies on-farm, an approach that government and industry need to heed if they are serious about facilitating change at the farm gate. An important element of capacity identified in this study is the ability to develop relevant skills and knowledge to change farming practices; this is described by Boxelaar and Kaine (2005) as learning capacity.

The development of a capacity and capability tool for self-assessment that indicates farmer capacity and capabilities required to successfully introducing change on-farm will allow education, training and extension programs to be directed into areas of greatest need and opportunity. Currently, industry needs analysis approaches tend to be based on the technical needs of farmers and fall short of providing a capacity and capability assessment. This research study has been successful in identifying a range of variables and associations between those variables that have the potential to be integrated into a change model that is specifically orientated towards the true needs of farmers.

### **6.2.3 Viewing extension as a social science and a profession**

Investment in extension by government has declined significantly in recent years, with governments restructuring and downsizing extension services with the expectation that the void would be filled by

the private sector (Marsh and Pannell 2000). The ability for farmers to manage change has been questionable, the result of a decline in the rate at which the capacity and capability of farmers have developed. Extension programs have tended to be dominated by a technical approach, and in many situations have focussed only on cropping enterprises (Ridley 2005), often failing to apply a broader systems perspective.

The change process is central to an effective extension system and should be viewed as a science requiring an adequate level of investment to achieve desired outcomes. The State Extension Leaders Network (SELN) comprising senior State Government agency representatives, define extension as a change process focussed on building the capacity for change through improved communication and information flows (Anon 2005). An attitudinal shift by government, industry and research and development organisations is now required to achieve impact and change across communities and industries. This of course would require investment of resources to rejuvenate extension networks and increase research capability and information flows (Marsh and Pannell 2000) that have become depleted over time.

There is the danger of extension not being sufficiently supported to maintain a critical mass of intellectual capacity and capability, a key requirement for facilitating the change process at the farm level. The withdrawal of government supported extension services in recent years has resulted in an imbalance in the credibility and independence in the provision of information to the farming community. Increasingly, information delivery has become linked to commercial outcomes driven by agribusiness (Hanson and Just 2001), whilst lacking social impact (Barnes 2001). The withdrawal of government extension services and the failure of the private industry to fill the void (Marsh and Pannell 2000) have been, to the detriment of many rural communities and industry groups. Inequity in government support, particularly in the lower rainfall districts of South Australia has been documented (Black 2004). A policy shift by government would be required to address this inequity.

There is a need for greater accountability of outcomes achieved through the provision of extension support by government in an effort to demonstrate capability and delivery of outcomes (Rivera and Alex 2006). Critical to this is the need to invest resources into building the capacity of extension officers, and develop extension research and evaluation methodologies. By measuring the impact and benefits arising from extension activities, it is then possible to make rational investment decisions (Fleischer et al. 2003) and demonstrate the full flow-on of benefits into the communities. It would seem that in many situations these flow-on benefits have not been fully quantified, thus resulting in a reduction in government investment due to incomplete or partial information on the full value of extension.

There are many providers of information within agricultural knowledge systems. The significance of the role that farmers themselves play as a valued information source is immense and has been clearly identified by this study. Farmers could play an even greater role in terms of mentoring and supporting each other in the adoption of new technologies. Early adopters of the technology provide local context for its relevance in the area and this local development is highly valued by the other farmers in the area (Llewellyn 2006).

### **6.3 INTRODUCING A NEW PARADIGM FOR EXTENSION DELIVERY**

This study has made a significant contribution towards the development of better understanding of adoptive behaviour amongst Australian farmers. The delivery of current agricultural extension programs, often limited by both available financial resources, and an understanding of the true nature of farmer decision-making has resulted in many programs failing to achieve significant change on the farm, and net impact at an industry level. The identification and use of farmer typologies provides the opportunity to develop public and private extension programs tailored to the socio-economic characteristics of farmers (Ertage et al. 2006, Sandford 2004).

As part of developing a new paradigm for the delivery of extension services to the grains industry, it is essential that a market research approach be adopted. In using this approach, it will be possible to focus extension efforts targeting those segments where impact can be achieved, and developing targeted messages within the context of local farming systems (Boland et al. 2005).

This particular approach has been developed and adopted by Statistics Canada, where a classification system of farmer typologies was developed in order to target government programs and policies according to the life stage, business intentions and expectations of farmers (Niekamp and Zafiriou 2000). Their program has some general and specific features that could well be applied to the farmers and the systems described in this study.

Whilst adoptive behaviour is an influencing characteristic, there are other determining characteristics such as farm size, farm business equity, whether the farmer is new to the industry (or contemplating retirement), whether or not they farm in a reliable district or a marginal environment, farmer attitude to risk and farmer conservatism and innovativeness. These characteristics are unique to each specific cluster identified in this study, and illustrate the complexities associated with the farmer sample used in this study. Through considering a number of these key characteristics in relation to capability and capacity of farmers, clusters of farmers having a positive future and those greatest at risk of leaving the industry can be identified. On this basis it is possible to develop extension programs that address the unique characteristics of such cluster groups, in order to maximise the opportunity for introducing change on-farm.

By having an understanding of the personal and situational characteristics associated with the farming population, it is possible to develop a means of targeting those farmers who wish to embrace change, and could be motivated to improve their management skills and overall profitability of the

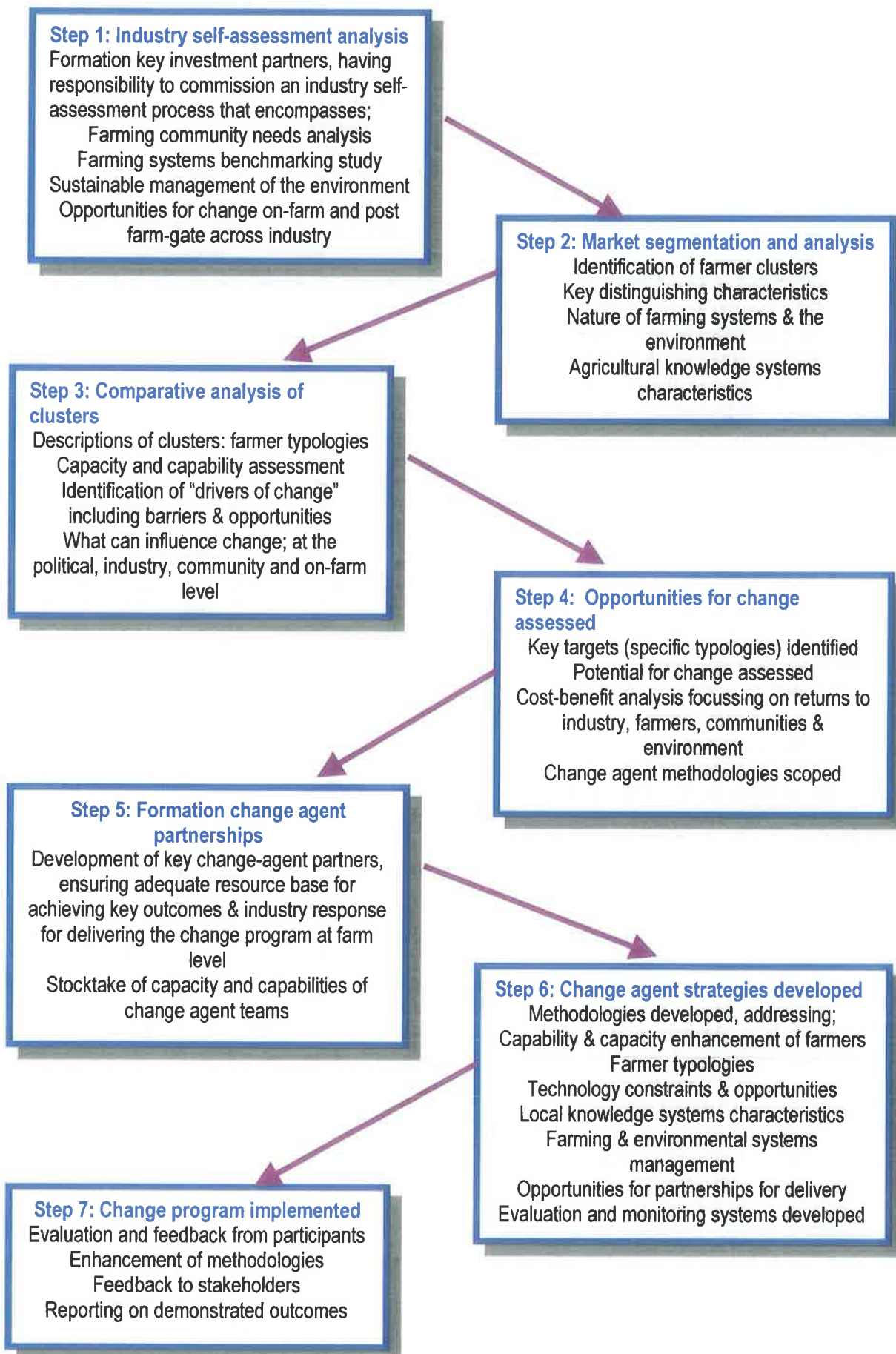
farm businesses. Part of this strategy is to identify the key drivers of change, and address specific barriers to the adoption of improved farming practices.

By having an understanding of the audience and the key outcomes to be achieved, it may be possible to better target specific programs in the context in which the extension program is to be delivered. If for example conservative farmers are characterised by low information access through printed sources but high participation in field days, then creating awareness about a new practice may be best demonstrated at field days as opposed to articles in printed or electronic media.

It is likely that there will be continued pressures on poor-performing farmers in to the future, which could force them to leave the industry (Kingwell and Pannell 2005). Strategies need to be developed to assist those farmers wishing to exit the industry if they consider that they have no future in farming. For remaining farmers, a program to enhance business capacity and personal capability skills needs to be developed.

It has been demonstrated that those involved in extension need to develop more directed and targeted extension programs. This requires a significant shift in traditional approaches, to a new paradigm that is reflected through a Market Segmentation Model for Change (MSMC). The MSMC incorporates key findings arising from this study, in an effort to develop innovative means of integrating a range of methodologies and understanding, in a simple 7-step process (Figure 6.1).

**Figure 6.1: Market Segmentation Model for Change (MSMC)**



Key elements of the MSMC are described;

#### Step 1: Industry self-assessment analysis

During this process, key partners with an interest in achieving change at the farm and industry level are engaged to initiate an industry self-assessment process that comprises the following key initiatives;

- Farming community needs analysis aimed at identifying opportunities for the enhancement of farming systems at a farm business and community level;
- Benchmarking studies aimed at identifying how individual farm businesses are performing, from productivity, adoption of best practice, management of sustainable resources and farm business performance perspective. This process aims to identify how individual farm businesses compare to others on a district, regional and industry basis. Specific benchmarks need to be continually reviewed and updated in order to ensure their relevance and applicability;
- Other personal and situational characteristics of farmers and their businesses;
- Identification of opportunities for change on-farm and post farm gate across industry, with stakeholder input.

#### **Step 2: Market segmentation and analysis**

The market segmentation process is important in terms of objectively analysing the information and data collected from step 1, and will be utilised in order to develop change agent strategies and approaches in steps 3 to 6. Outcomes achieved through the market segmentation process will include the following;

- Farmer clusters, including the identification of their distinguishing characteristics - that may include personal and situational, adoption of best practices, farm business performance;
- The nature of farming systems and the environment, including opportunities for enhancement;
- The distinguishing characteristics of local agricultural knowledge systems aimed toward development of change strategies.

### **Step 3: Comparative analysis of farmer clusters**

Based on the cluster analysis (step 2), the distinguishing features associated with each of the clusters will be identified, leading to an assessment of the capacity and capabilities associated with the cluster groupings. This will assist in identifying the 'drivers of change', including the barriers and opportunities to the adoption of technologies. Identification of the influences of change, in terms of what factors are influenced at the political, industry community and farm level will be required, in order to develop systems of change that incorporate appropriate engagement amongst those that can influence change.

### **Step 4: Opportunities for change assessed**

Through analysing the characteristics associated with each of the farmer typologies (step 3), the potential for change across each of the cluster groups can be assessed. The relative efficiency of uptake of the technologies can be determined, in terms of responses in behaviour characteristic of each of the farmer typologies. This will then provide indications of the benefits to be generated, providing valuable data for cost-benefit analysis. Based on this analysis, initial change agent approaches and methodologies can then be conceptualised, and tailored to the characteristics and requirements of the different farmer typology groupings.

### **Step 5: Formation of change-agent partnerships**

In order to secure adequate resources for achieving the desired outcomes, it will be necessary to ensure that adequate resources and partnerships are developed and maintained. This is a continuous process that should be considered at all stages of the MSMC. Developing change-agent partnerships will also assist in securing industry support, and responsiveness across government, industry, agribusiness and farming communities.

### **Step 6: Change agent strategies developed**

Specific change agent methodologies required to achieve the desired change are then developed. Such approaches need to address key issues such as capability and capacity enhancement of farmers, farmer typologies, technology constraints and opportunities, local knowledge systems characteristics, farming and environmental management systems. This will result in a variety of approaches, aimed at addressing the preferred means of information acquisition (by farmers), learning styles and decision-making processes. Opportunities for forming additional partnerships for the delivery of programs likewise need to be explored (in order to broaden the expertise and depth of delivery activities and strategies). Evaluation and monitoring systems will also need to be developed and put in place.

### **Step 7: Implementation of change-program**

The change program is implemented, to the targeted audience. Monitoring and evaluation is undertaken, in order to identify opportunities for enhancing delivery, and to ensure demonstrated outcomes are quantified as part of the reporting (or accountability) process. Opportunities for further program improvement are identified as part of a continuous improvement process.

## **6.4 RESEARCH LIMITATIONS**

With the knowledge and experience gained from this research study it is possible to identify areas where the research approach and outcomes could be improved. Following the analysis of results it has been possible to identify those variables considered critical for influencing adoption behaviour. Therefore, in a follow-up study it would be possible to develop a questionnaire with fewer variables but still be able to achieve similar outcomes.

As complex as it seems, the methodology adopted in this study can be further refined and applied to other agricultural sectors, in order to better describe specific characteristics and dynamics unique to

those industries. This would assist in the targeting of specific change processes and tailor specific technology adoption / extension initiatives. This research approach has provided a methodology that will allow better targeting of extension and communication programs that are aimed at maximising impact and change at the farm level. Such an approach will provide the opportunity to segment and target specific farmer typology within a given population. This will assist in maximising the desired outcomes of such a project investment.

## **6.5 RECOMMENDATIONS FOR FUTURE WORK**

This study has identified the opportunity to develop and introduce the Market Segmentation Model for Change (MSMC) as a means of introducing the outcomes from this study. The MSMC model utilises a market segmentation approach to identifying the personal capability and capacity of farmers to embrace change. The MSMC model provides a structured approach to identifying specific segments of the farming population that would benefit from targeted extension programs, through addressing specific skill and capability development opportunities. The MSMC model has the potential to provide government and industry with an overview of the constraints that limit the ability of farmers to manage change, and assist in the development of industry policy and development. It is recommended that investment be directed at developing this model further, in order to develop methodologies and strategies for introducing change programs in agriculture.

## **6.6 CONCLUSIONS**

Through utilising a market segmentation approach, this study has successfully identified specific groupings of farmers with like characteristics, leading to farmer typology descriptives. This has been achieved through analysis of results generated from a robust population of some 2,472 respondents, providing a high degree of confidence in the findings. The analysis identified that of all the farming population studied, 22.3% do not have the capacity or capability to introduce change on farm, and are limited by either personal capabilities or available resources. A further 26.2% of the population

have the skills and capabilities to adopt new technology, but are limited by either the financial resources of the business or small land area available for farming operations. Finally, the majority of the population (51.5%) has the capacity and capability to adopt improved farming practices. This understanding will assist in more effective targeting of extension and communication programs through identifying those groups that are more likely to either respond to, or have the capacity to introduce improved farming systems.

There are valid reasons as to why the adoption of particular practices does not occur, with the influence of the environment (for example rainfall) being a major factor in shaping farmer attitude to risk which in turn affects adoptive behaviour. The decision to adopt a new farming practice involves a complex set of decision-making processes within the context of the farmers' own personal and situational factors. Farmer attitude to new technology, risk management capabilities, conservatism and business environment will all play a role in the final decision relating to adoption or rejection of the innovation. The decision leading to adoption/non-adoption is a logical one, from the perspective of farmers themselves. It is the interpretation of such farmer decisions by persons external to the farming business that creates the degree of judgemental angst. There are community pressures evident in relation to the adoption of new technologies, with often the 'conservative' types of farmers being viewed as 'benchmarks' by the more progressive farmers whom are aiming to improve their farming systems. The stereotyping of such farmers as 'laggards' has done little to explain the logical reasons for non-adoption; as identified through this study.

It is evident that in the past all farmers have been targeted for particular extension messages and activities, on the assumption that most should have the interest and motivation to be involved in such activities. This general approach by the extension or research agency has failed to appreciate the diversity in the farming population. Some farmers are not willing to participate; many do not have the capability or desire to be involved. Some farmers are in serious financial trouble. It does not matter

how beneficial the technology may be, financial resources limit them. Other farmers may simply be looking toward retirement and are happy with just the lifestyle advantages associated with their profession. Segmentation of the farming population based upon personal and situational characteristics and adoptive behaviour will assist in the better targeting of extension programs.

By creating strategies that seek to better understand the farming population, it would be possible to target resources at those who are in a position to embrace change on-farm, and others that have the potential to be influenced. Some farmers have either no desire to change nor do they necessarily have the capacity to do so. Whilst it is easy to stereotype such farmers; they often have valid reasons for not accepting new technologies. The targets of the extension message and the avenue of delivery are critical to achieving adoption. The adoption environment is extremely complex, with a wide range of intervening variables and characteristics. Not all respondents will be in a position to adopt which may relate to the desire to, or the capacity to change. Extension delivery systems need to be well targeted, segmentation of the audience will assist in achieving higher adoption levels.

In order to achieve widespread adoption of new opportunities for sustainable agricultural practices in Australia, the adoptive behaviour of the farming population needs to be better understood. Whilst recent approaches to extension have adopted a farming systems perspective, they have tended to apply a blanket approach to information delivery, failing to address and meet the needs of all farmer participants. There is a need to develop a range of approaches to extension that specifically meet the needs and address the personal and situational characteristics of the diverse farming population. This can be achieved through developing a market segmentation approach to extension delivery, and improving the understanding of adoption behaviour amongst research and extension professionals, based upon the MSMC model. This requires new thinking and coordinated investment by government and industry.

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A B

# CROPPING 2000 SURVEY



AUGUST 1997

This industry initiative is supported by



Jay Cummins  
9 Old North Road,  
Clare SA 5453  
23 July 1997

Dear SA grain grower,

A couple of weeks ago you would have received by post a card from the Minister for Primary Industries, the Hon. Rob Kerin introducing you to the CROPPING 2000 SURVEY. Well here it is!

The survey has been mailed to all grain growers across SA, over 4 500 in total. To refresh your memory, the aim of the survey is to help identify the information needs of SA grain growers like yourself, in addition to benchmarking the current state of field crop production and management practices undertaken by grain growers. It would be appreciated if the main decision maker/manager of your farming business could take time out to complete the survey – the more involved the better!

The study is supported through Primary Industries SA and a Grains Research and Development Corporation (GRDC) Research fellowship which I am undertaking through the Roseworthy campus of the University of Adelaide. The survey is also endorsed by grower groups, as well as marketing, research and extension organisations (GRDC, SAFF, SACBH, the AWB, the Agricultural Bureau movement, PISA SARDI, University of Adelaide and others), all of whom will benefit directly from the information generated through the survey.

This questionnaire should take approximately an hour or less to complete. Whilst I appreciate that this is a considerable input of your time, it is important that we receive as many responses as possible, in order to obtain a true reflection of the industry's current farming practices and information/technology needs.

**All questions will be treated with strictest confidentiality, no identity of the source of information will be made.**

**Your reply by 15 August 1997** will be greatly appreciated, a reply paid free-post envelope is enclosed for your use.

As a small incentive for your time input, I invite you to enter a draw for the chance to win either a copy of the "Tractor Log Book" (ideal for keeping your paddock operations and activities in the one book), or the "Southern Region Winter Crop Summary" book (for planning all of your winter cropping activities)! There are 1 500 books to win!

There is also a major prize of \$500 worth of selected Kondinin Farming Group publications, but to be eligible for all of these prizes, your survey must be returned by 15 August 1997. Simply complete the enclosed card provided, and either include the card with your survey response or post it separately.

Should you require further information in relation to any matter regarding the survey, you can contact me by telephoning and leaving a message on 015 619 590, and I will return your call as soon as possible.

Looking forward to your positive support and response,

Jay Cummins  
University of Adelaide  
Department of Agronomy and Farming Systems

CROPPING  
2000  
SURVEY

# CROPPING 2000 SURVEY

ALL INFORMATION WILL BE TREATED WITH STRICTEST CONFIDENCE

## SURVEY GUIDELINES

1. Please answer each question to the best of your ability, instructions for each question are provided.
2. Please tick within boxes, and circle numbers, in order to avoid "borderline" responses.
3. Completed surveys should be returned by 15 August 1997 in the reply paid envelope provided. If you require further information or assistance in completing the survey, contact survey co-ordinator Jay Cummins, telephone 015 619 590.
4. You are also invited to participate in the draw to win \$500 worth of farming publications, or one of 1 500 Tractor Log Books or Southern Region Winter Crop Sowing Guides. Complete the card provided to enter this draw.

**NOTE:** *If you are no longer involved in farming, or if your farm business has received duplicate surveys, please indicate this on the card provided with the survey (same card as for the prize draw), and return it by post.*

*This will help us to establish the true response rate from the survey, and improve the accuracy of our interpretations from the survey.*

Q1. What is your postcode?

Q2. Please list the main Hundred/s that your farm is located in (limit to 1 or 2)

Q3. Is the farm that you manage either owned by you, your family or family trust? (tick one box only)

YES

NO  <sup>2</sup>  
(proceed to question 5)

Q4. How long has the farm been in your family? (Indicate number of years)

Q5. How long have you been involved in farming? (indicate number of years)

Q6. How long have you assumed full (or joint) responsibility in managing this farm business? (indicate number of years)

Q7. What is your age category? (tick the appropriate box)

less than 20 years

 <sup>1</sup>

40-49 years

 <sup>4</sup>

20-29 years

 <sup>2</sup>

50-59 years

 <sup>5</sup>

30-39 years

 <sup>3</sup>

60 years or more

 <sup>6</sup>

Q8. What is your highest level of formal education? (please tick one box only)

Primary school only

 <sup>1</sup>

Trade or certificate course (TAFE, agricultural or technical college)

 <sup>4</sup>

Part of secondary school

 <sup>2</sup>

Tertiary education (diploma or degree course)

 <sup>5</sup>

Completion secondary school

 <sup>3</sup>

Post-graduate tertiary training

 <sup>6</sup>

Other (please specify).....

CROPPING  
2000



SURVEY

## FARM CHARACTERISTICS

Q9. Please complete the following details in relation to rainfall and farm areas:

Average annual rainfall (*mm*)

Total farm area owned (*ha*)

Total arable area owned (*ha*)

Additional arable area leased/sharefarmed (*ha*)

## SOIL AND LAND MANAGEMENT

Q10. We are interested to find out how much of a concern a range of land management issues are on your farm (Column A) and whether these problems are getting worse or not (Column B).  
Circle one number in each column for each land management issue.

Soil/land management	A. How much of a concern is this problem on your farm? 1 = not an issue (no need to answer part B) 2 = limited concern 3 = a recognised problem (some loss in income and modified farming practices necessary) 4 = major threat (significant income loss, and major changes in farming practices required)				B. What is the current situation on your farm 1 = situation improving 2 = no change in extent of problem 3 = situation getting worse		
	1	2	3	4	1	2	3
1. Dryland salinity	1	2	3	4	1	2	3
2. Wind erosion	1	2	3	4	1	2	3
3. Sheet/rill erosion	1	2	3	4	1	2	3
4. Wind erosion	1	2	3	4	1	2	3
5. Gully erosion	1	2	3	4	1	2	3
6. Hardsetting soils	1	2	3	4	1	2	3
7. Drainage/waterlogging	1	2	3	4	1	2	3
8. Soil organic matter decline	1	2	3	4	1	2	3
9. Water repellence	1	2	3	4	1	2	3
10. General soil fertility	1	2	3	4	1	2	3
11. Soil phosphorus levels	1	2	3	4	1	2	3
12. Soil nitrogen levels	1	2	3	4	1	2	3
13. Trace element deficiency	1	2	3	4	1	2	3
14. Soil acidity	1	2	3	4	1	2	3
15. Native vegetation decline	1	2	3	4	1	2	3
16. Rabbits	1	2	3	4	1	2	3

## AGRONOMIC FARM MANAGEMENT PRACTICES

**Q11.** Please indicate how often (if at all) the following practices are carried out on your farm;  
(tick one box for each farming practice example)

**Note\*:** Where a particular practice relates to a specific enterprise that is not carried out on your farm tick the "Not Applicable" column. For example, you may not grow barley, therefore applications of fungicidal seed dressings do not apply to your farming situation.

Practice	Never practised <small>1</small>	Practised in the past, but no longer <small>2</small>	Sometimes practised <small>3</small>	Always practised <small>4</small>	Will try out in next 2-3 years <small>5</small>	Not applicable to my farm* <small>6</small>
1. Gross margin planning						
2. Follow a grain marketing plan						
3. Plan rotations using disease resistant varieties						
4. Soil test for fertility						
5. Grade and apply dressings to seed sown						
6. Using fungicidal seed dressings on barley						
7. Adjust seeding rates according to seed size and sowing conditions						
8. Cultivate dry soils						
9. Burn stubbles						
10. Use knock-down herbicides prior to crop sowing						
11. Adjusting fertiliser rates according to target yields and paddock fertility						
12. Use narrow points on seeding equipment						
13. Monitor weeds prior to selecting herbicide product and rate						
14. Tissue test crops for trace elements						
15. Sow medic pastures						
16. Control red-legged earthmite in pastures						
17. Spray/graze pastures for broad leaf weed control						
18. Spray pastures with a selective grass herbicide (eg Fusilade)						

## AGRONOMIC FARM MANAGEMENT PRACTICES (cont.)

Q11. Continued from previous page. Please indicate how often (if at all) the following practices are carried out on your farm. (tick one box for each farming practice example)

Practice	Never practised 1	Practised in the past, but no longer 2	Sometimes practised 3	Always practised 4	Will try out in next 2-3 years 5	Not applicable to my farm* 6
19. "Spray top" pastures for grass control in Spring						
20. Rotate herbicide groups to avoid resistance						
21. Broadcast phosphorus fertiliser to pastures						
22. Green manure legume crops/pastures						
23. Practice a long fallow (cultivate usually before October)						
24. Insure the majority of crop for hail/fire						
25. Inspect on-farm grain storage for insect pests						
26. Conduct on-farm comparisons/trials						
27. Replace old cereal seed with new certified seed as the need arises						

## CROP YIELDS ON YOUR FARM

By completing the following information, we will have an indication of the relative achievements in crop production across SA in recent years, as well as an indication of the future outlook of the SA grain industry.

- Q12. Please indicate for those crops that you grow listed in the table below;
- A. The average yield you would have expected if you were farming 10 years ago.
  - B. What you consider to be an average yield nowadays.
  - C. What average yield you would expect to be achieving on your farm in 5 years time.

*if you work in "bags per acre", please indicate this.*

Crop Type	A. Average yield 10 years ago (t/ha)	B. Average yield nowadays (t/ha)	C. Yield increase in 5 years time (t/ha)
Wheat			
Barley			
Canola			
Grain legumes (specify) .....			

## CROPPING ACTIVITIES

We are interested to learn of your cropping intentions in future years. This will help us identify future cropping trends and industry development opportunities and assist in planning for your future information needs.

Q13. In the following table please;

A. Indicate for the crops you grow, the average area sown (over the last 5 seasons).

B. Indicate the expected area to be sown to each crop type (including any new crops not currently grown) in 5 years time (the year 2002).

*(complete for only those crops you are currently growing, or intend to be growing in 5 years time)*

Crop Type	A. Average area sown over last 5 years (ha)	B. Expected area to be sown in 5 years time (ha)
Wheat (APW/Hard)		
Wheat (durum)		
Wheat (feed)		
Barley (feed)		
Barley (Malt)		
Oats (milling)		
Oats (feed)		
Oaten hay/mix		
Triticale		
Cereal rye		
Field Peas		
Faba beans		
Lupins		
Lentils		
Chickpeas		
Canola		
Vetch (grain)		
Vetch (pasture)		
Sown medic pasture		
Others .....		

## WHEAT PROTEIN LEVELS

Q14. What has been your average wheat protein level achieved on your farm over the last 5 years?  %  
(indicate % protein)

Q15. Over the last 5 years, has there been a trend for wheat protein levels on your farm to be;  
(tick appropriate box)

Increasing  1      Decreasing  2      Remaining static  3

## YOUR PERSONAL OUTLOOK ON FARMING

Q16. The following table contains a number of statements about farming. Do you agree or disagree with them?  
(please tick the appropriate box for each statement)

STATEMENT	strongly agree	agree	neither agree or disagree	disagree	strongly disagree
The key to good farming is really about minimising costs					
I would not try a new chemical until it was well proven in the district					
I regard myself as a fairly conservative and traditional farmer					
Quality assurance of grain produced on my farm is an issue I need to incorporate into my management					
Direct drilling of crops does not work in the district I farm					
Due to the weather, there is not much point planning more than a few months ahead in farming					
If there are new methods or grain varieties, I like to be one of the first in the district to try them out					
Marketing of the grain I produce is best left to the experts, such as the Australian Wheat Board					
I think that there is significant opportunity to increase the yield of my main crops grown					
There is little financial reward offered for targeting high protein wheat production on my farm					
It's difficult to make on-farm decisions nowadays due to too much information being available					
I am concerned about the sustainability of farming practices on my farm					
I am concerned about the sustainability of farming practices in my district					

## ON-FARM ADOPTION OF TECHNOLOGIES

The following pages relate to your involvement in a number of different farming practices, crops and technologies. We are interested to learn more about how you find out about new technology, if you have tried them out, and if you have identified any problems in trying to apply these technologies to your own farming environment. By completing the following, we will be able to establish if other farmers have similar problems, and hopefully make the process of introducing technology on-farm an easier process in the future.

Simply respond to each of the questions, providing the appropriate answers and following the arrows according to your response. Answers you provide need only be brief and to the point.

8

CROPPING  
2000  
SURVEY 

Q17.

A

### WHEAT PROTEIN MANAGEMENT

Maximising the opportunity for growing high protein and high yielding wheat, through sound crop rotations, and depending on farming environment, utilising any or all of the following; additional N fertiliser, quality legume pastures and crops in the rotation, adequate weed and disease control etc.

**Are you aware of this practice?**

YES

NO

Proceed to next example

From where and when did you first hear about this practice?  
Where .....  
When (year) .....

Have you tried the practice?

YES

NO

What information source was most influential in your decision to try it?  
.....

Are there any reasons why you haven't tried it?  
.....  
.....

Proceed to next example

When did you first use the practice?  
Year.....

Are you still practising it?

YES

NO

When did you stop the practice and why?  
.....  
.....  
.....

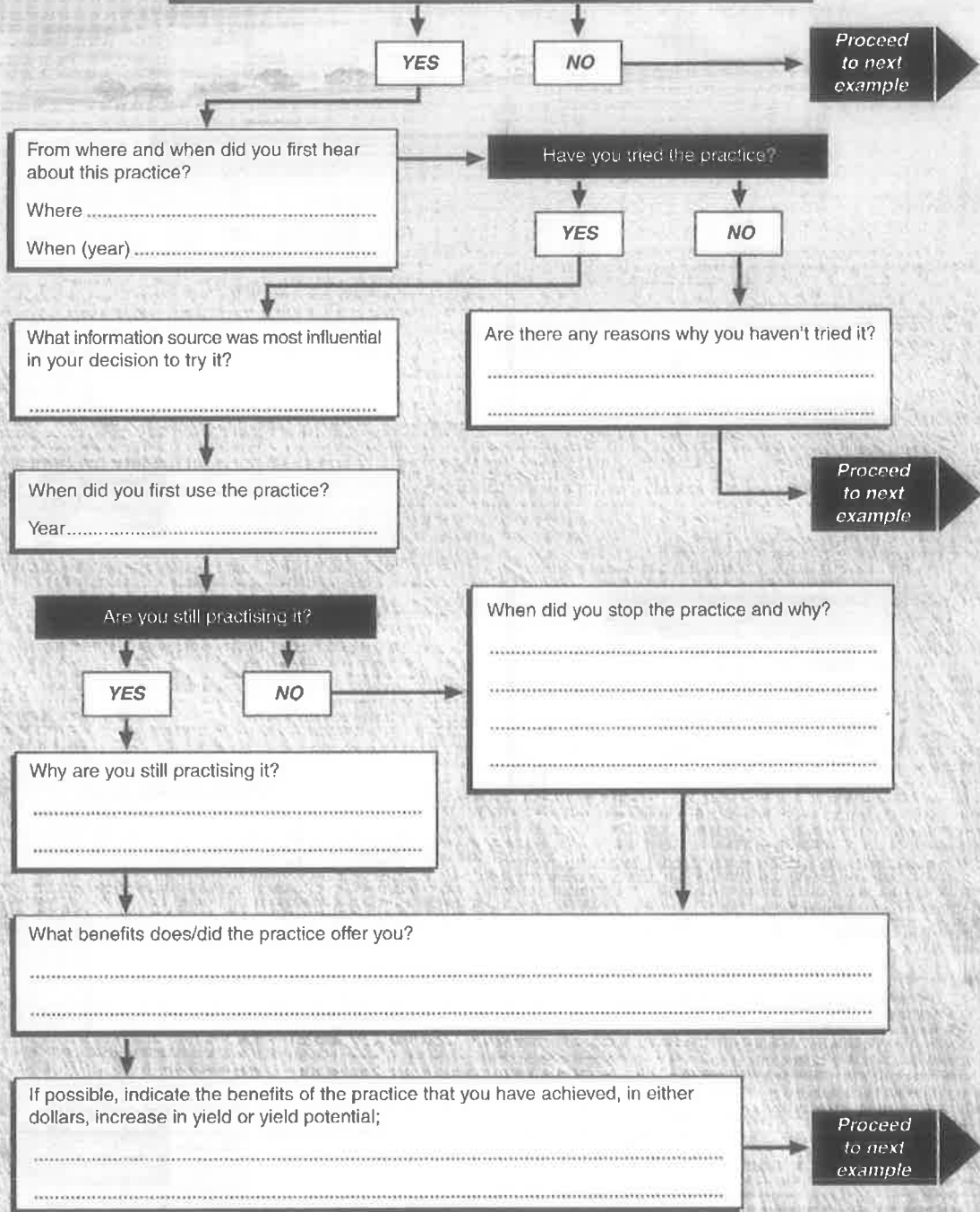
Why are you still practising it?  
.....  
.....

What benefits does/did the practice offer you?  
.....  
.....

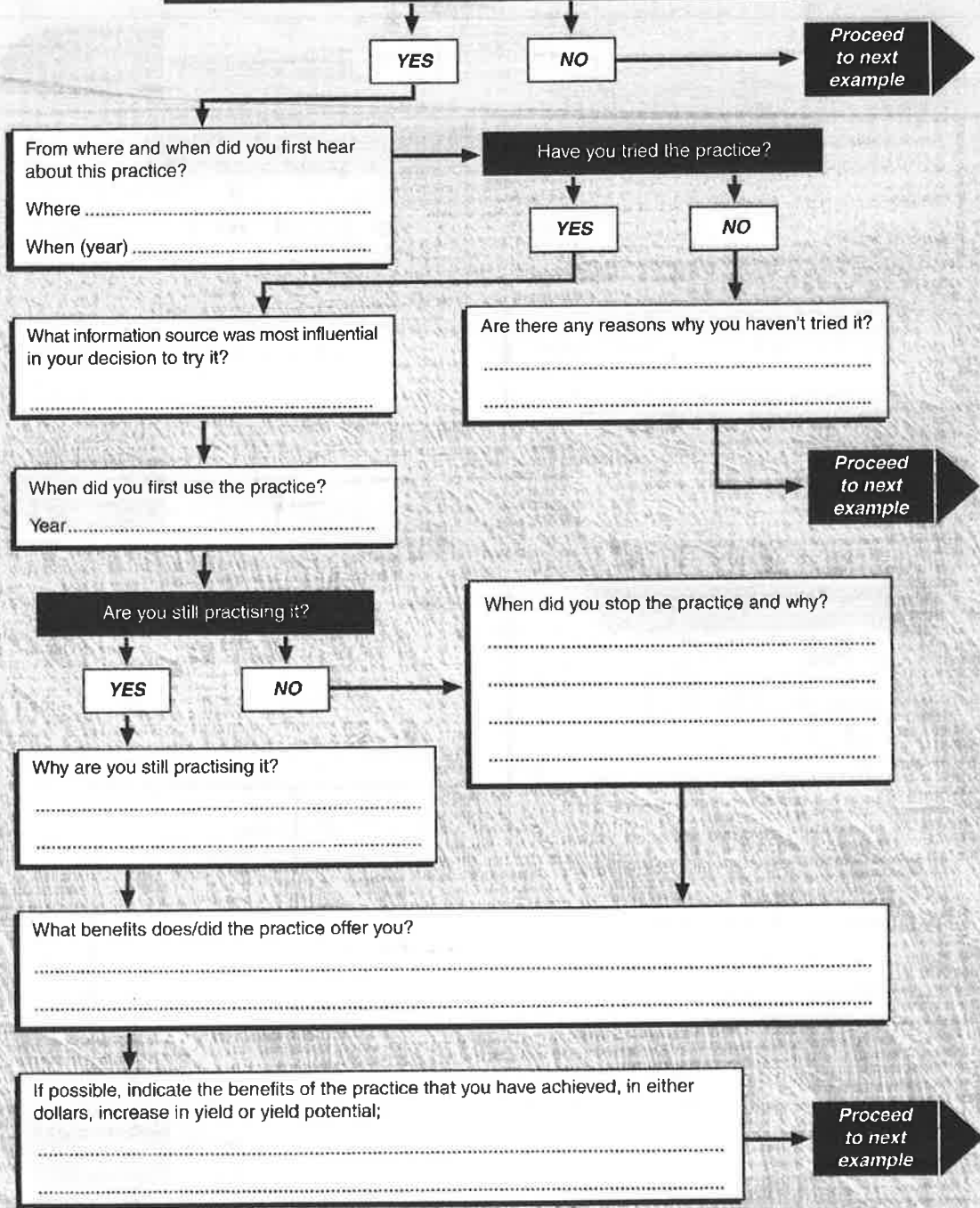
If possible, indicate the benefit of the practice that you have achieved, in either dollars, increase in yield or yield potential;  
.....  
.....

Proceed to next example

**GRAIN MARKETING RISK MANAGEMENT PROGRAM**  
 Involving regular monitoring of grain prices, consideration to utilising forward contracts, futures, on-farm trading of grain, and other associated strategies.  
**Are you aware of this practice?**

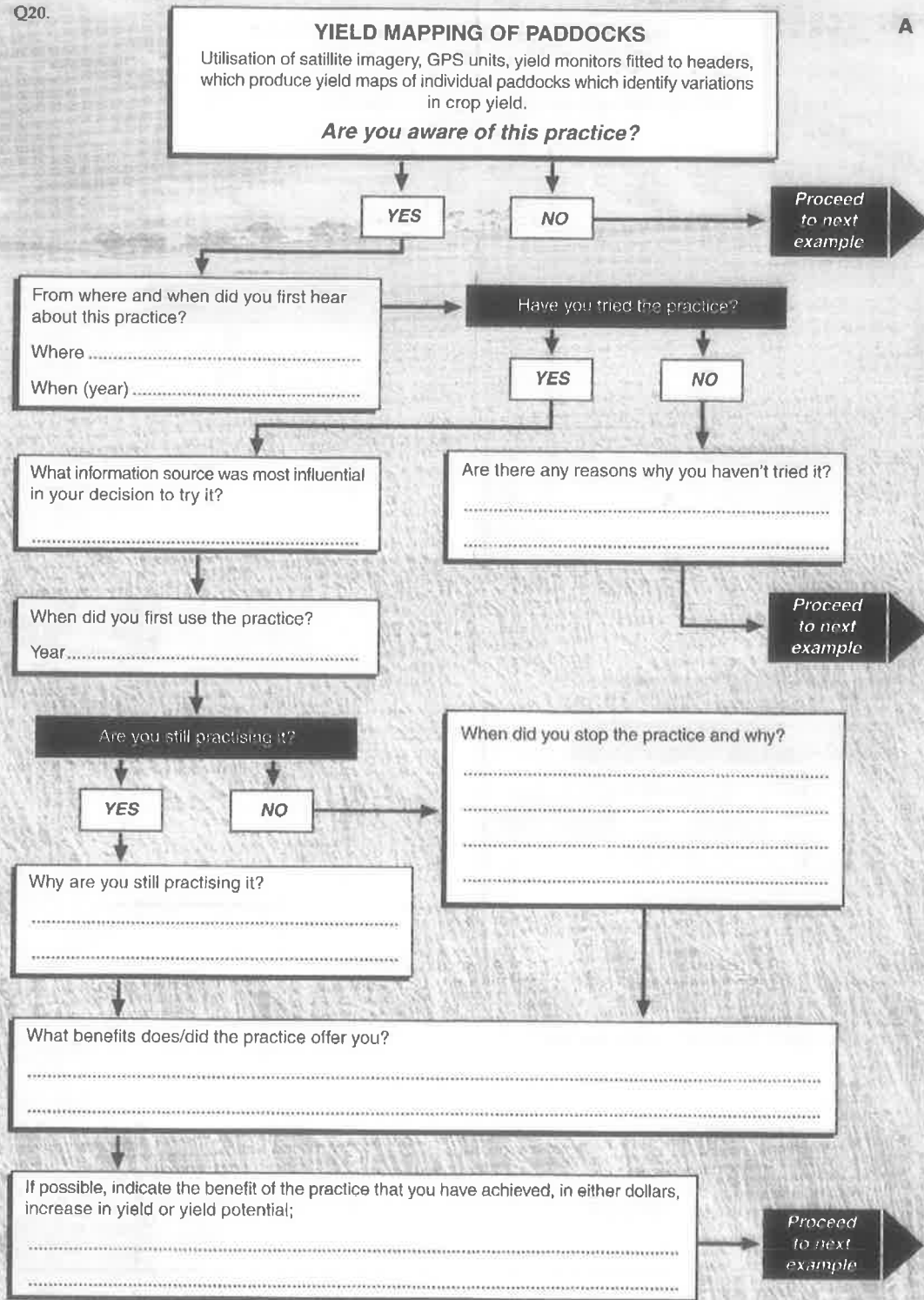


**HERBICIDE RESISTANCE MANAGEMENT**  
 Utilising management techniques such as monitoring for resistance plants, rotation of herbicide products used, minimising herbicide usage (particularly from high risk herbicide groups), using a range of control techniques.  
**Are you aware of this practice?**

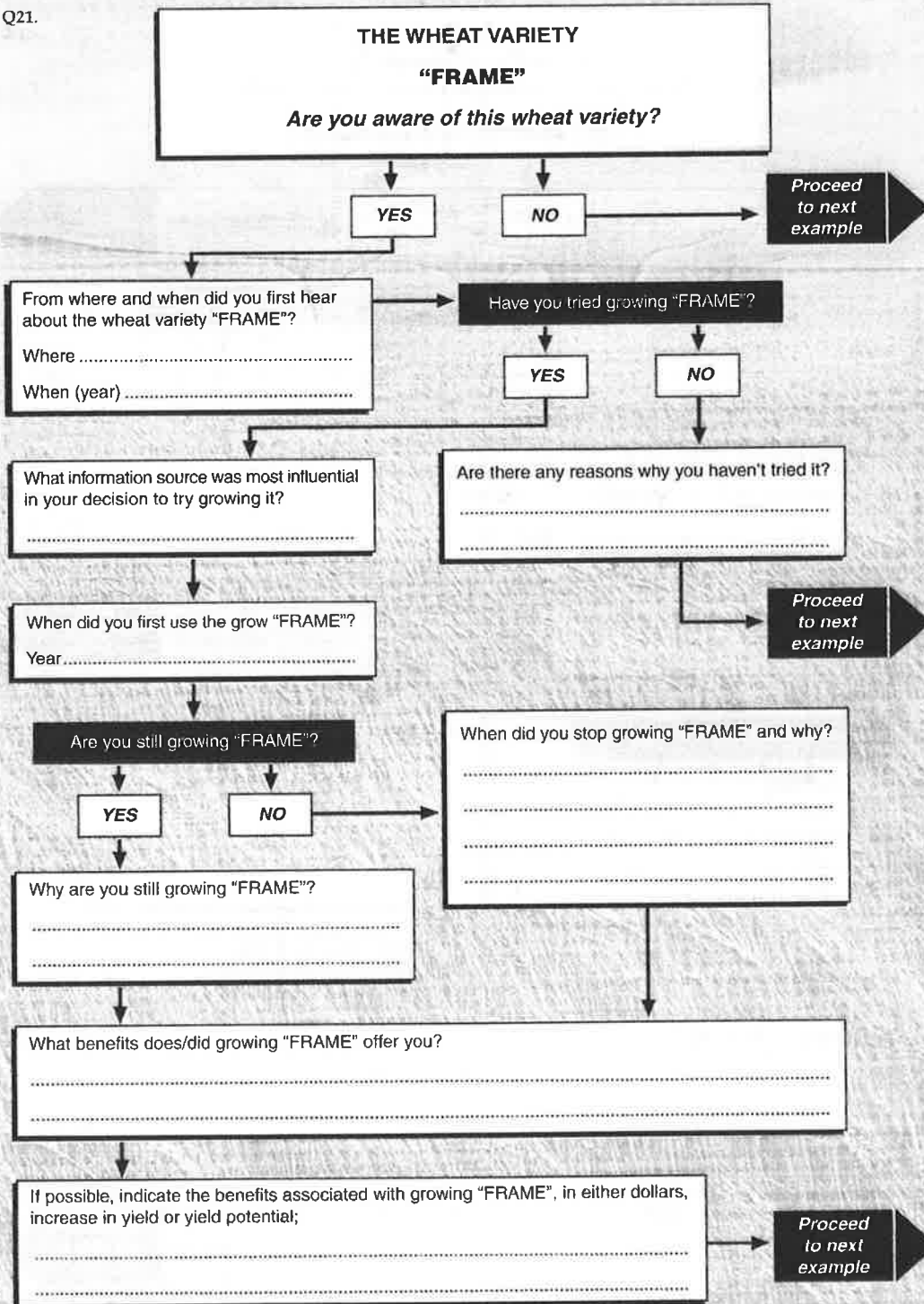


Q20.

A



Q21.





Q23.

**MINIMUM TILLAGE – DIRECT DRILLING**  
Involving the practice of a single or minimal soil disturbance prior to seeding, weed control achieved primarily through the use of herbicides, machinery modifications to assist in handling paddock residues.  
**Are you aware of this practice?**

**YES**

**NO**

**Proceed to next question**

From where and when did you first hear about this practice?  
Where .....  
When (year) .....

**Have you tried the practice?**

**YES**

**NO**

What information source was most influential in your decision to try it?  
.....

Are there any reasons why you haven't tried it?  
.....

**Proceed to next question**

When did you first use the practice?  
Year .....

**Are you still practising it?**

**YES**

**NO**

When did you stop the practice and why?  
.....  
.....  
.....

Why are you still practising it?  
.....  
.....

What benefits does/did the practice offer you?  
.....  
.....

If possible, indicate the benefits of the practice that you have achieved, in either dollars, increase in yield or yield potential;  
.....  
.....

**Proceed to next question**

## WHAT ARE YOUR INFORMATION SOURCES?

We are interested to find out from where you access information and how valuable you find specific information sources. This will allow us to better target your information needs, and enhance information sharing amongst those servicing the industry.

Q24. Please indicate how frequent you use each source (column A), and if you use the particular information source, how useful each source is (column B). **Circle the number for each which best matches your answer.**

NOTE: If never used (Column A, score of 1), no need to complete Column B (How useful).

Information Source	A. How Frequent					B. How useful				
	1	2	3	4	5	1	2	3	4	5
Local Newspaper	1	2	3	4	5	1	2	3	4	5
Stock Journal	1	2	3	4	5	1	2	3	4	5
Australian Grain magazine	1	2	3	4	5	1	2	3	4	5
Australian Farm Journal magazine	1	2	3	4	5	1	2	3	4	5
Kondinin Farming Ahead magazine	1	2	3	4	5	1	2	3	4	5
GRDC Ground Cover Magazine	1	2	3	4	5	1	2	3	4	5
Fact sheets	1	2	3	4	5	1	2	3	4	5
PISA Crop & Livestock Harvest report	1	2	3	4	5	1	2	3	4	5
Callum Downs Grains Newsletter	1	2	3	4	5	1	2	3	4	5
ABC Country Hour (radio)	1	2	3	4	5	1	2	3	4	5
ABC Landline (TV)	1	2	3	4	5	1	2	3	4	5
Neighbours	1	2	3	4	5	1	2	3	4	5
Family members	1	2	3	4	5	1	2	3	4	5
Accountant/financial planner	1	2	3	4	5	1	2	3	4	5
Chemical Company Representative	1	2	3	4	5	1	2	3	4	5
Fertiliser Company Agronomist	1	2	3	4	5	1	2	3	4	5
Private agricultural consultant	1	2	3	4	5	1	2	3	4	5
Chemical reseller/Stock Agent	1	2	3	4	5	1	2	3	4	5
SARDI Research Officer	1	2	3	4	5	1	2	3	4	5
PISA District Agronomist/Adviser	1	2	3	4	5	1	2	3	4	5
Marketing Authorities AWB/ABB	1	2	3	4	5	1	2	3	4	5
The Internet (WWW)	1	2	3	4	5	1	2	3	4	5
PISA-fax	1	2	3	4	5	1	2	3	4	5
Kondinin Farm Line service	1	2	3	4	5	1	2	3	4	5
Other (please specify .....	1	2	3	4	5	1	2	3	4	5

## FARM GROUPS AND FIELD DAYS

We are interested to find out how your level of contact with various farm groups and field days, and how useful you find these in relation to gaining new ideas and information that can be used on farm.

Q25. Please indicate your level of involvement with each (column A), and how useful you find each of these groups and field days (column B) by circling the appropriate number for each in the following table.  
**Note: For field days, indicate whether or not you usually attend them with either a yes or no.**

If never involved (Column A, score 1), no need to complete Column B (How useful).

Farm Group or Field Day	A. Level of involvement					B. How useful each				
	1 = never involved 2 = once or twice per year 3 = three to four times per year 4 = at least on a monthly basis 5 = used at least fortnightly					1 = no use 2 = interesting, but no practical use 3 = of some use 4 = very useful 5 = extremely useful				
Landcare group	1	2	3	4	5	1	2	3	4	5
Pro-graze group	1	2	3	4	5	1	2	3	4	5
Right Rotations group	1	2	3	4	5	1	2	3	4	5
Agricultural Bureau group	1	2	3	4	5	1	2	3	4	5
TOPCROP group	1	2	3	4	5	1	2	3	4	5
Crop Science Society	1	2	3	4	5	1	2	3	4	5
SAFF Branch group	1	2	3	4	5	1	2	3	4	5
Grain marketing discussion group	1	2	3	4	5	1	2	3	4	5
Agricultural consultants group	1	2	3	4	5	1	2	3	4	5
Chemical reseller's discussion group	1	2	3	4	5	1	2	3	4	5
Property Management Planning group	1	2	3	4	5	1	2	3	4	5
Farm Management 500 group	1	2	3	4	5	1	2	3	4	5
Minnipa Research Centre Field Day	1	2	3	4	5	1	2	3	4	5
IAMA Technology Centre Field Day	usually attended YES / NO					1	2	3	4	5
Agricultural Bureau Spring Field Days/field walks/sticky beak days	usually attended YES / NO					1	2	3	4	5
Agricultural Bureau Conferences	usually attended YES / NO					1	2	3	4	5
Stubble Handling Field Days	usually attended YES / NO					1	2	3	4	5
Hart Field Day	usually attended YES / NO					1	2	3	4	5
Riverland Field Days (gadget days)	usually attended YES / NO					1	2	3	4	5
Lucindale Field Days	usually attended YES / NO					1	2	3	4	5
Karoonda Field Day (Sheep Fair)	usually attended YES / NO					1	2	3	4	5
Eyre Peninsula Field Days (Cleve)	usually attended YES / NO					1	2	3	4	5
Turretfield Research Centre Field Day	usually attended YES / NO					1	2	3	4	5
Yorke Peninsula Field Day (Paskeville)	usually attended YES / NO					1	2	3	4	5
GRDC AgExpo (Roseworthy/Birchip)	usually attended YES / NO					1	2	3	4	5
Other (please specify .....	usually attended YES / NO					1	2	3	4	5

## BARRIERS TO INTRODUCING NEW PRACTICES ON-FARM

*We are interested to learn of any specific farming practices that you would like to introduce on-farm, but for one reason or another, you are unable to do so. This will help us to identify the major barriers to on-farm adoption of new technology and practices, allowing for future action by industry as a whole.*

- Q26. Please indicate if there are any new farming practice/s that you would like to introduce on your farm, but in some way prevents you from doing so;

.....  
.....  
.....

- Q27. What do you consider to be the main barriers/constraints preventing you from introducing the new practice?

.....  
.....  
.....

## PRIORITIES FOR INVESTMENT ON-FARM AND IN RESEARCH, DEVELOPMENT AND EXTENSION

*We are interested to find out (as part of a "needs analysis") what you consider to be priorities for expenditure on your farm business, as well as research, development and extension activities. Information relating to research and extension needs that are provided by respondents to the survey will be summarised and forwarded to the GRDC, SARDI, Primary Industries SA, University of Adelaide, SAFF and the Advisory Board of Agriculture.*

- Q28. If you were given \$1 million dollars to spend on your farm business, where would you direct these funds (and why)?

.....  
.....  
.....  
.....

- Q29. If you were given \$10 million dollars to spend on servicing the needs of farmers in SA, where would you direct these funds (and why)?

.....  
.....  
.....  
.....  
.....

## FARM FINANCIAL INDICATORS

All information will be treated with **STRICT CONFIDENTIALITY** – no identification of the source of the information will be made. (If you do not wish to answer this question, we respect your right not to).

We are interested to identify the equity of farm businesses, and how this relates to production and uptake of new technology. Please complete the following information, to the best of your ability;

- Q30. What is the market value of your farming property that you own, if you were to sell it tomorrow on the open market? (including fixed improvements, but excluding stock & machinery)
- Q31. What is the value of your machinery?
- Q32. What is the value of your livestock?
- Q33. What is the total amount of farm borrowing's (including loans, liabilities and other debts associated with your farm business)

## FARM MANAGEMENT

Q34. Which of the following statements best describes the degree of your involvement in decision making on your farm? (tick one box only)

- 1 I always consult with others before making farm management decisions
- 2 I sometimes consult with others before making farm management decisions
- 3 I sometimes have **minor input** into farm management decisions **made by others**
- 4 I never consult with others before making farm management decisions
- 5 I am **never involved** in making farm management decisions

Q35. How do you feel about the long term financial viability of your farm? (tick appropriate box)

- 1 Very confident about the future
- 2 Reasonably confident about the future
- 3 A little concerned about the future
- 4 Very concerned about the future

## FARMING SKILLS

Q36. How do you compare yourself with other farmers in your district in relation to; (for each skill example, tick the appropriate box)

SKILL	one of the best <sub>1</sub>	above average <sub>2</sub>	average <sub>3</sub>	below average <sub>4</sub>
Cropping management				
Livestock management				
Engineering/machinery modifications				
Computing				
Grain marketing				
Farm business management				

## This ends the questionnaire, WELL DONE!

Should you wish to make additional comments in relation to the survey, feel free to do so in the following box:

Additional comments

.....

.....

.....

.....

.....

.....

.....

.....

## Remember to fill out the card for the prize draw!

Return the survey and card in the reply paid envelope (no postage stamp required). PLEASE return by 15 August 1997. If you have misplaced this envelope, the address to send your survey and card to is:

### **CROPPING 2000 SURVEY**

Free Post 037  
9 Old North Road  
CLARE SA 5453

18 July 1997


Dear SA grain grower,


In the next week you will receive by post a copy of the **CROPPING 2000 SURVEY** questionnaire. The main decision maker/manager of your farming business will be invited to complete this survey. All information will be treated with the strictest confidentiality.

The survey aims to identify the information needs of SA grain growers, in addition to benchmarking current field crop production and management practices carried out on-farm. This industry supported study is being undertaken independently by Jay Cummins, whom has been awarded a Grains Research and Development Research Corporation Fellowship to examine the efficiency of technology adoption and information dissemination in the Australian grains industry (based at the University of Adelaide's Roseworthy campus).

Your response will enhance the efficiency at which information and technology is transferred and adopted on-farm.

The survey receives my full support and that of industry, and will provide you with a chance to actively contribute to the on-farm development of SA's grain industry.

  
 Hon. Rob Kerin  
 Minister for Primary Industries.



**A message from SACBH**

SACBH have provided the preprinted name and address labels used for the distribution of all material for the **CROPPING 2000 SURVEY**. As SACBH has maintained complete control of the membership data base used in this printing, the confidentiality of your personal details is assured.

*Supported by Industry*

<p>Neil Robjohns Customer Services Manager SACBH</p> 	<p> Grains Research &amp; Development Corporation</p> <p> THE UNIVERSITY OF ADELAIDE</p>			
<p>Michael Thomas Executive Officer Grains - SAFF</p> 	<p>Dr Peter Gibson Chief Scientist Field Crops Research</p> 	<p>Ray Kemith Chairman Right Rotations Program (ABA)</p> 	<p>Barry Windle Director Agricultural Industries, PISA</p> 	<p>David Thomas State Manager AWB</p> 



If undeliverable, return to  
Cropping 2000 Survey  
9 Old North Road  
CLARE SA 5453

**POSTAGE PAID**  
**OFF PEAK**  
**AUSTRALIA**

**CROPPING**  
**2000**  
**SURVEY**



9 Old North Road  
CLARE SA 5453  
5 August 1997

**POSTAGE PAID**  
**OFF PEAK**  
**AUSTRALIA**

Dear SA grain grower,

This is just a brief note to remind you that if you haven't yet responded to the **CROPPING 2000 SURVEY** sent to you at the end of July, there is still time to do so.

It would be appreciated if you could respond to this survey by the 22 August 1997. If you cannot locate your copy of the survey sent to you, please contact me on mobile 015 619 590, leave a message and I will forward to you a replicate survey immediately.

If you have already returned this survey, I would like to take this opportunity to extend my sincere appreciation of the time you have put into completing the survey. The industry, I am sure, will benefit from your input.

Kind regards,

Jay Cummins  
**CROPPING 2000 SURVEY** Project Coordinator



**REGISTRATION  
form**

PLEASE REPLY BY AUGUST 1, 1998

Group Name:	
Location	
Contact Person:	
Phone:	
Fax:	
Which month/s best suit your group? (TICK BOXES)	
JULY '98	
AUGUST '98	
SEPT '98	
OCT '98	
NOV '98	
When is the best time of the day to run a workshop?	
Morning	Afternoon
Evening	
Are there specific date/s that you wish to nominate for your workshop?	
Date/s:	
How many group members are likely to attend?	
Number:	

Please send to:

JAY CUMMINS  
CROPPING 2000 WORKSHOP  
FREEPOST 037,  
CLARE SA 5453  
or Fax: (08) 8842 1391  
Enquiries phone: 0418 818 995

**SAMPLE  
program (draft only)**

- Introduction, & program outline
- CROPPING 2000 survey findings, overview and discussion on a State and regional basis
- How does your farming system compare with your neighbours? Benchmarking exercise examining production, information sources and 'best practice'
- Survey feedback & comments  
COFFEE/TEA BREAK
- Local Information networks - where do you gather your information?
- Making better decisions - what influences your decision-making?
- Summary and close

**HOW DOES  
your group get involved?**

Simply complete the registration form attached, and forward to Jay Cummins by 1 August '98.

The sooner you register, the greater is your chance of being involved, as only 15 workshops will be conducted across South Australia this year.

Specific workshops may be considered for those servicing the industry, please register your interest.



**AN INVITATION IS EXTENDED TO  
SA Graingrowers**

**THE CROPPING 2000  
workshop series**

*A participative review of the  
Cropping 2000 Survey*

*An opportunity to benchmark  
your farm's productivity & 'best  
practice' with others, and  
review your production goals*



CUT ALONG LINE

## **CROPPING 2000** *workshop series program*

Over 2,500 of South Australia's grain growers last year participated in the CROPPING 2000 survey. Information provided in the survey helped identify where farmers are at in relation to;

- Farmer achievement over the last 10 years in terms of *improved grain production*
- Cropping intentions and *production potential* over the next 5 years
- Extent of technology adoption, including the reason, *why* farmers *choose not to adopt* particular farming practices
- Farm information *sources and value*
- Research and extension *funding priorities* and *community needs*

Survey information has since been documented, to the point where it is now summarised on a district, regional and statewide basis.

Farm groups across SA now have the opportunity to assist in the interpretation of the survey findings, through participation in a series of CROPPING 2000 Workshops to be conducted between July and November this year.

Each workshop will utilise locally derived information sourced from the CROPPING 2000 survey. This provides your group with the unique opportunity to compare your farming practices and use of technology with "the average" for your district and region, and provide comments that will help in local interpretation.

### **WHAT WILL THE WORKSHOP** *offer you?*

The CROPPING 2000 workshop program will provide you with an opportunity to:

- Be briefed on the interim survey findings
- Participate in the local interpretation of survey findings
- Compare your own "best practice" and productivity with other farmers on a local, district, regional and statewide basis through a simple benchmarking exercise
- Assist in the next phase of the research program, that aims to identify in greater detail information sources and factors influencing on-farm decisions.

### **WHO** *can be involved?*

The CROPPING 2000 Workshop program is targeted at farm groups across South Australia involved in broadacre crop production. Farmers and partners involved with on-farm decision-making are encouraged to attend as a family unit.

All farm groups are invited to participate, such as Bureau and SAFF groups, groups associated with consultants or resellers, or groups working with programs such as PMP, TOPCROP and Landcare.

### **WHO** *will run the workshops?*

The workshops will be run by Jay Cummins, who is conducting the CROPPING 2000 survey and research program as part of his post-graduate research program at the Roseworthy Campus of the University of Adelaide.

### **HOW LONG** *will the workshops take?*

The workshops will take around 3 hours, and are best run during the daytime, (although some evening workshops will be available).

### **HOW MANY WORKSHOPS** *will be run and when?*

The workshops will be limited to the first 15 groups who register, & will be conducted between July and November this year.

### **HOW MANY** *can attend?*

Ideally, 8 - 12 people per workshop is best, with 6 still being viable. The workshops are restricted to those involved in on-farm grain production.

### **WHAT** *is the cost?*

There are no costs associated with attendance at the CROPPING 2000 workshop program as your participation in this workshop will contribute further to on-going research.

### **FURTHER** *information*

Available from Jay Cummins;  
Telephone 0418 818 995,  
Fax 08 8842 1391,  
E-mail: [jcummins@capri.net.au](mailto:jcummins@capri.net.au).

**APPENDIX D: VARIABLES USED FOR DATA ANALYSIS**

Variable Code	Variable Description	Unit measure	Source	Number of observations	Mean	Median	Std Dev
<b>Personal Characteristics</b>							
AGE_RANGE	Age of Respondents	Categories	Survey	2378	4.1	4.0	1.1
EDUC	Level of education Achieved	Categories	Survey				
YR_INVOL	Years involved in farming	Number of years	Survey	2363	29.6	30.0	12.3
YR_MANAG	Years involved in Managing the farm business	No years	Survey	2361	19.3	19.0	11.5
INNOVAT	Degree of innovativeness of respondents, reflected in attitudes toward technology & innovation	Unit	Based on net response to no key attitudinal statements relating to conservative farm mgt practices & adoption characteristics.	2264	0.28		4.1
STEWARM	Land Stewardship, reflected through adoption of, and attitudes towards sustainable farming practices on-farm and across the district	Unit	Calculated as a cumulative score according to attitudes towards sustainability of farming practices on-farm and across district, concerns for land management issues, and adoption of sustainable farming practices (associated with minimum tillage)	2416	5.79		4.26
OUTLOOK	Positive outlook on farming	Unit	Calculated on the basis of holding positive attitudes to new technology, ability to increase crop yields in the future, positive attitude towards longer term farm financial viability				
VIABILITY	Score associated with concern towards long term financial viability	Unit	Survey				

**APPENDIX D: VARIABLES USED FOR DATA ANALYSIS continued**

Variable Code	Variable Description	Unit measure	Source	Number of observations	Mean	Median	Std Dev
SALINITY	Concern associated with dryland salinity on-farm	Unit	Survey, response to on-farm concern associated with dryland salinity	2339	1.5	1.0	0.7
EROSION	Concern associated with wind, sheet, gully and wind erosion on-farm	Unit	Survey, average response for wind, sheet, gully and wind erosion concerns on-farm	1771	6.7	6.0	1.9
SOIL_STR	Concern associated with soil structure	Unit	Survey, aver response for hard setting soils & drainage / water logging concerns on-farm	2278	3.4	3.0	1.4
S_FERT	Concern associated with soil fertility	Unit	Survey, average response for soil om decline, general soil fertility, soil P and N levels and trace element deficiency concerns on-farm.	2255	10.4	10.0	2.9
ACIDITY	Concern associated with soil acidity.	Unit	Survey, response to on-farm concern for soil acidity.	2301	1.4	1.0	0.7
<b>Farm Characteristics</b>							
APR_OCT	April to October Growing Season Rainfall	Mm of rainfall	"Rainman" Bureau of Meteorology data linked to location of respondent	2319	303.7	301.0	63.1
ARABLE	Total arable farm area	Hectares	Survey	2315	1291.1	970	1082.4
TOT_CRP	Total area in crop (1997)	Hectares	Survey	2366	751.7	580.0	648.3
ACRP_INT	Cropping intensity	Percentage	Percentage of total arable farm area designated as being cropped in 1997	2167	61.0	58.7	22.4
<b>Farm Financial Performance</b>							
EQUITY	Equity in farm business	Percentage	Total value of farm assets minus farm borrowings	1835	85.9	89.0	14.0

**APPENDIX D: VARIABLES USED FOR DATA ANALYSIS continued**

Variable Code	Variable Description	Unit measure	Source	Number of observations	Mean	Median	Std Dev
VAL_TOT	Total value of farm assets	Dollars	Survey (value of land, fixed improvements, machinery and livestock)	1875	1190 629	945000	939518
VAL_DEBT	Total value of farm borrowings	Dollars	Survey	1895	1464 83	100000	189333
VAL_MACH	Value of Farm Machinery	Dollars	Survey	1903	2344 50	188000	203063
VAL_FARM	Value of farming land	Dollars	Survey	1903	9069 34	70000	777902
DEBT_T	Ratio of farm debt to total tonnes of grain produced	\$ debt per tonne of grain produced	Total farm debt (\$) divided by total tonnes (of all grains produced on-farm)	1814	140.5 3		197.3
MACH_T	Ratio of farm machinery value to total tonnes of grain produced on-farm	\$ per tonne of grain	Total machinery value (investment) divided into total tonnes (of all grains produced on-farm)	1827	214.0 5		230
<b>Crop Production Performance</b>							
WH_NOW	Wheat yield achieved nowadays	Tonnes per hectare	From survey	2292	2.2	2.2	0.9
INC2_WH	Increase in wheat yield expected over next 5 year period	Percentage	Based on comparing rate of wheat yield increase from 1997 to 2002.	1937	18.4	16.7	14.0
WPOT_NOW	Potential wheat yield achieved nowadays	Percentage	Current yield compared with potential yield based on April to October rainfall	2202	58.3	56.6	17.5
BPOT_NOW	Potential barley yield achieved nowadays	Percentage	Current yield compared with potential yield based on April to October rainfall	2070	53.4	53.1	14.7
WPOT_RK	Ranking of respondents according to potential wheat yield achieved	Quartile	Current yield compared with potential yield based on April to October rainfall, with population divided into quartiles	2202	1.5	1.0	1.1

**APPENDIX D VARIABLES USED FOR DATA ANALYSIS continued**

Variable Code	Variable Description	Unit measure	Source	Number of observations	Mean	Median	Std Dev
TOT_TONNES	Total Tonnes of all grain crops produced on-farm	Tonnes	Total area multiplied by average yields for each crop type	2289	1300		1287.7
TONNES	Number of tonnes of wheat and barley produced	Tonnes	Survey, calculated by multiplying area sown by average yield for crop type.	2289	1098.3	848.0	1147.2
BROAD_RT	Percentage of broadleaf crops sown to total crops	Percentage	Total area broadleaf crops (pulse, canola pastures) divided into total crop area sown	2366	17.3		0.156 (X100?)
<b>Information Access</b>							
IS_PRIN	Number and frequency of access of printed information sources	Unit	Survey, calculated from total information sources multiplied by frequency of each	2364	63.1	60.5	31.2
IS_ELEC	Number and frequency of access of electronic information sources	Unit	Survey, calculated from total information sources multiplied by frequency of each	2364	29.3	29.5	17.9
IS_PERS	Number and frequency of access of personal information sources	Unit	Survey, calculated from total information sources multiplied by frequency of each	2364	54.6	50.0	35.4
IS_GRP	Number and frequency of access of group based activities	Unit	Survey, calculated from total group sources multiplied by frequency of each	2364	3.1	3.0	2.1
IS_FDAY	Number and frequency of access of field day sources	Unit	Survey, calculated from total field day sources multiplied by frequency of each	2364	7.4	8.0	3.0
<b>Adoption Characteristics</b>							
AV3_LAG	Average time lag to adoption	Days	Cumulative period (days) from awareness to adoption of three different innovations (wheat protein management, grain marketing, herbicide resistance)	2143	500.8	243.5	895.2
BESTP	Adoption of Best Practice (for all best practice examples)	Unit	Adoption score relating to 16 specific "best practice" practices, weighted according to "level of complexity and innovativeness" associated with each. Scores adjusted according to level of adoption, 1.0 complete adoption, 0.5 for partial or dis-adoption	2416	8.83		1.93

APPENDIX D VARIABLES USED FOR DATA ANALYSIS continued

Variable Code	Variable Description	Unit measure	Source	Number of observations	Mean	Median	Std Dev
Bestp_S	Adoption of Best Practice (for all best practice examples)	Unit	Adoption score relating to 16 specific "best practice" farming practices, equal weightings, but scores adjusted according to level of adoption, 1.0 complete adoption, 0.75 for partial adoption, 0.5 for dis-adoption and 0.25 if intend to try the technology.				
CRP_EST	Adoption of Best Practice associated with Crop Establishment	Unit	Adoption score use of seed dressings, adjust of seeding rates, knock down herbicides narrow sowing pts on machinery	2416	4.1	4.0	0.9
CRP_NUT	Adoption of Best Practice associated with Crop Nutrition Practices	Unit	Adoption score use of soil and plant testing, adjusting rates, and sowing medic pastures	2416	3.1	3.0	1.0
WEEDPEST	Adoption of Best Practice associated with Weed and Pest Management	Unit	Adoption score relating to monitoring weeds prior to control, controlling red legged earth mite, spray grazing pastures for broadleaf weed control and / or selective grass weed control, grass weed control in spring and rotating herbicide groupings.	2416	4.6	5.0	1.4
GRAIN_MM	Adoption of Best Practice associated with Grain Marketing and grain handling.	Unit	Adoption score following a grain marketing plan, inspecting storage for pests, conducting on-farm trials and comparisons, and replacing old cereal seed with new certified seed.	2416	3.2	3.0	0.8
MAN_ROT	Adoption of Best Practice associated with Managing risks associated with Crop rotations	Unit	Adoption score relating to gross margin planning, planning rotations using resistant varieties and insuring the majority of the crop.	2416	2.6	3.0	0.6
Q11_SOME	Adoption of innovations sometimes and / or all time	Unit	Level of adoption - data from survey	2416	18.3	19.0	3.6
Q11_ALL	Adoption of innovations all of the time	Unit	Level of adoption - data from survey	2416	9.8	10.0	3.7

### Principal Component Analysis - Variables for Analysis

PCA1	PCA2	PCA3	PCA4	PCA5
<b>Personal</b>	<b>Personal</b>	<b>Personal</b>	<b>Personal</b>	<b>Personal</b>
AGE_RANGE	AGE_RANGE	AGE_RANGE	AGE_RANGE	AGE_RANGE
EDUC	EDUC	EDUC	EDUC	EDUC
YR_INVOL	YR_INVOL	YR_INVOL	YR_INVOL	YR_INVOL
YR_MANAG	YR_MANAG	YR_MANAG	YR_MANAG	YR_MANAG
INNOVAT	INNOVAT	INNOVAT	INNOVAT	INNOVAT
STEWARM	STEWARM	STEWARM	STEWARM	STEWARM
OUTLOOK	OUTLOOK	OUTLOOK	OUTLOOK	OUTLOOK
VIABILITY	VIABILITY	VIABILITY	VIABILITY	VIABILITY
SALINITY	SALINITY	SALINITY	SALINITY	SALINITY
EROSION	EROSION	EROSION	EROSION	EROSION
SOIL_STR	SOIL_STR	SOIL_STR	SOIL_STR	SOIL_STR
S_FERT	S_FERT	S_FERT	S_FERT	S_FERT
ACIDITY	ACIDITY	ACIDITY	ACIDITY	ACIDITY
<b>Farm Charact</b>	<b>Farm Charact</b>	<b>Farm Charact</b>	<b>Farm Charact</b>	<b>Farm Charact</b>
APR_OCT	APR_OCT	APR_OCT	APR_OCT	APR_OCT
ARABLE	ARABLE	ARABLE	ARABLE	ARABLE
TOT_CRP	TOT_CRP	TOT_CRP	TOT_CRP	TOT_CRP
ACRP_INT	ACRP_INT	ACRP_INT	ACRP_INT	ACRP_INT
<b>Farm Financial</b>	<b>Farm Financial</b>	<b>Farm Financial</b>	<b>Farm Financial</b>	<b>Farm Financial</b>
EQUITY	EQUITY	EQUITY	EQUITY	EQUITY
VAL_TOT	VAL_TOT	VAL_TOT	VAL_TOT	VAL_TOT
VAL_DEBT	VAL_DEBT	VAL_DEBT	VAL_DEBT	VAL_DEBT
VAL_MACH	VAL_MACH	VAL_MACH	VAL_MACH	VAL_MACH
VAL_FARM	VAL_FARM	VAL_FARM	VAL_FARM	VAL_FARM
DEBT_T	DEBT_T	DEBT_T	DEBT_T	DEBT_T
MACH_T	MACH_T	MACH_T	MACH_T	MACH_T
<b>Crop Production</b>	<b>Crop Production</b>	<b>Crop Production</b>	<b>Crop Production</b>	<b>Crop Production</b>
WH_NOW	WH_NOW	WH_NOW	WH_NOW	WH_NOW
INC2_WH	INC2_WH	INC2_WH	INC2_WH	INC2_WH
WPOT_NOW	WPOT_NOW	WPOT_NOW	WPOT_NOW	WPOT_NOW
BPOT_NOW	BPOT_NOW	BPOT_NOW	BPOT_NOW	BPOT_NOW
WPOT_RK	WPOT_RK	WPOT_RK	WPOT_RK	WPOT_RK
TOT_TONNES	TOT_TONNES	TOT_TONNES	TOT_TONNES	TOT_TONNES
TONNES	TONNES	TONNES	TONNES	TONNES
BROAD_RT	BROAD_RT	BROAD_RT	BROAD_RT	BROAD_RT
<b>Information Access</b>	<b>Information Access</b>	<b>Information Access</b>	<b>Information Access</b>	<b>Information Access</b>
IS_TOTS	IS_TOTS	IS_TOTS	IS_TOTS	IS_TOTS
IS_TOTEL	IS_TOTEL	IS_TOTEL	IS_TOTEL	IS_TOTEL
IS_TOTPER	IS_TOTPER	IS_TOTPER	IS_TOTPER	IS_TOTPER
IS_TOTPRI	IS_TOTPRI	IS_TOTPRI	IS_TOTPRI	IS_TOTPRI
IS_TOTGRP	IS_TOTGRP	IS_TOTGRP	IS_TOTGRP	IS_TOTGRP
IS_TOTFDAY	IS_TOTFDAY	IS_TOTFDAY	IS_TOTFDAY	IS_TOTFDAY
IS_TOTM	IS_TOTM	IS_TOTM	IS_TOTM	IS_TOTM
IS_PRIN	IS_PRIN	IS_PRIN	IS_PRIN	IS_PRIN
IS_ELEC	IS_ELEC	IS_ELEC	IS_ELEC	IS_ELEC
IS_PERS	IS_PERS	IS_PERS	IS_PERS	IS_PERS
IS_GRP	IS_GRP	IS_GRP	IS_GRP	IS_GRP
IS_FDAY	IS_FDAY	IS_FDAY	IS_FDAY	IS_FDAY
AV3_LAG	AV3_LAG	AV3_LAG	AV3_LAG	AV3_LAG
BESTP	BESTP	BESTP	BESTP	BESTP
Bestp_S	Bestp_S	Bestp_S	Bestp_S	Bestp_S
CRP_EST	CRP_EST	CRP_EST	CRP_EST	CRP_EST
CRP_NUT	CRP_NUT	CRP_NUT	CRP_NUT	CRP_NUT
WEEDPEST	WEEDPEST	WEEDPEST	WEEDPEST	WEEDPEST
GRAIN_MM	GRAIN_MM	GRAIN_MM	GRAIN_MM	GRAIN_MM
MAN_ROT	MAN_ROT	MAN_ROT	MAN_ROT	MAN_ROT
Q11_SOME	Q11_SOME	Q11_SOME	Q11_SOME	Q11_SOME
Q11_ALL	Q11_ALL	Q11_ALL	Q11_ALL	Q11_ALL

Highlighted variables = the variables chosen for the Principal Component Analysis

## APPENDIX E: Attitudinal responses by survey respondents

Statement	Attitudinal Responses % of respondents for each question				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. The key to good farming is really about minimising costs	13.1 (n=308)	28.9 (n=681)	27.4 (n=645)	25.8 (n=609)	4.8 (n=114)
2. I would not try a new chemical until it was well proven in the district	8.5 (n=202)	28.5 (n=679)	24.5 (n=585)	35.0 (n=836)	3.5 (n=84)
3. I regard myself as a fairly conservative and traditional farmer	8.0 (n=189)	37.8 (n=899)	21.1 (n=502)	29.1 (n=691)	4.0 (n=96)
4. QA of grain produced on my farm is an issue that I need to incorporate into my management	13.7 (n=324)	65.3 (n=1539)	15.9 (n=374)	4.4 (n=104)	0.7 (n=17)
5. Direct drilling of crops does not work in the district I farm	5.3 (n=126)	12.8 (n=305)	32.4 (n=773)	35.7 (n=851)	13.9 (n=331)
6. Due to the weather, there is not much point planning more than a few months ahead	3.9 (n=94)	12.6 (n=301)	9.3 (n=223)	51.1 (n=1221)	23.1 (n=552)
7. I like to be one of the first in the district to try new methods or grain varieties	4.7 (n=111)	30.2 (n=718)	43.0 (n=1021)	20.8 (n=494)	1.4 (n=33)
8. I think that there is significant opportunity to increase the yield of my main crops grown	12.1 (n=288)	59.8 (n=1426)	20.1 (n=479)	7.7 (n=183)	0.4 (n=10)
9. It's difficult to make on-farm decisions nowadays due to too much information being available	1.9 (n=45)	11.6 (n=275)	26.8 (n=638)	52.2 (n=1243)	7.5 (n=178)

## APPENDIX F: Personal skills assessment for respondents

Specific skill area	Comparative rating			
	One of the best	Above average	Average	Below average
Cropping management (n=2208)	8.7 (n=193)	40.7 (n=899)	49.6 (n=1094)	1.0 (n=22)
Livestock management (n=2132)	7.7 (n=165)	33.9 (n=723)	54.3 (n=1158)	4.0 (n=86)
Engineering / machinery (n=2191)	6.3 (n=137)	29.9 (n=655)	46.1 (n=1009)	17.8 (n=390)
Computing (n=2132)	2.5 (n=53)	12.7 (n=271)	26.6 (n=567)	58.2 (n=1241)
Grain Marketing (n=2179)	1.8 (n=39)	11.6 (n=253)	57.7 (n=1258)	28.9 (n=629)
Farm Business (n=2205)	4.9 (n=107)	32.2 (n=709)	57.7 (n=1273)	5.3 (n=2205)

**APPENDIX G: Soil and Land Management Concerns (selected conditions)**

Soil & Land Management Condition	Degree of on-farm concern % of respondents			
	Not an issue	Some concern	Recognised problem	Major threat
Dryland salinity (n=2268)	64.5	23.6	10.2	1.7
Wind erosion (n=2278)	23.2	42.9	29.5	4.3
Soil organic matter decline (n=2243)	35.0	44.1	19.8	1.6
Non-wetting sands (n=2245)	55.7	23.4	16.3	4.6
Soil fertility (in general) (n=2270)	18.3	51.0	28.5	2.2
Soil phosphorus levels (n=2266)	22.4	52.8	23.2	1.6
Soil nitrogen levels (n=2271)	12.9	52.9	31.8	2.5
Trace element deficiency (n=2256)	22.0	50.3	25.8	2.0
Soil acidity (n=2231)	69.2	22.0	7.5	1.3

**APPENDIX H: Level of consultation in farm decision making**

Region	Degree of involvement / consultation in Farm management decisions				
	Always consult with others	Sometimes consult with others	Never consult with others	minor input decisions made by others	Never involved in management decisions
South East (n=162)	42.0 (n=68)	54.9 (n=89)	1.2 (n=2)	1.9 (n=3)	0
Mallee (n=340)	30.9 (n=105)	60.3 (n=205)	3.8 (n=13)	5.0 (n=17)	0
North (n=715)	39.6 (n=283)	52.9 (n=378)	4.6 (n=33)	2.8 (n=20)	0.1 (n=1)
Yorke (n=350)	40.9 (n=143)	53.4 (n=187)	3.4 (n=12)	2.3 (n=8)	0
Eyre (n=615)	35.6 (n=219)	56.8 (n=349)	4.6 (n=28)	2.9 (n=18)	0.2 (n=1)
Average (n=2195)	37.5 (n=823)	55.4 (n=1215)	4.1 (n=89)	3.0 (n=66)	0.1 (n=2)

**Appendix I: Confidence in the long-term financial viability of the farm business**

Region	Degree of confidence / concern			
	Very confident	Reasonably confident	A little concerned	Very concerned
South East (n= 163)	20.9 (n=34)	36.8 (n=60)	30.7 (n=50)	11.7 (n=19)
Mallee (n=340)	16.2 (n=55)	39.1 (n=133)	33.5 (n=114)	11.2 (n=38)
North (n=713)	19.1 (n=136)	40.8 (n=291)	29.3 (n=209)	10.8 (n=77)
Yorke (n=350)	22.6 (n=79)	47.4 (n=166)	20.6 (n=72)	9.4 (n=33)
Eyre (n=624)	17.0 (n=106)	45.4 (n=283)	25.8 (n=161)	11.9 (n=74)
Average (n=2203)	18.8 (n=427)	42.6 (n=969)	27.4 (n=624)	11.2 (n=254)

**APPENDIX J: Value of farm assets and liabilities across regional South Australia**

<b>Region</b>	<b>Market value of farm \$'000</b>	<b>Machinery value \$'000</b>	<b>Livestock value \$'000</b>	<b>Total value of farm assets \$'000</b>	<b>Total farm borrowing \$'000</b>	<b>Net Equity %</b>
South-East	1,211	219	104	1,541	213	85.3
Mallee	624	189	44	862	111	85.4
North	1,121	247	44	1,418	174	86.6
Yorke Pen.	1,146	255	31	1,427	130	89.1
Eyre Pen.	604	232	43	880	127	83.7
Average				1,184		85.8

**APPENDIX K: Wheat crop yields past (1987), present (1997) and future (2002)**

Region	Average Wheat Yield 10 years ago (1987) t/ha	Average wheat yield nowadays (1997) t/ha	Wheat Yield Increase 1987-1997 (%)	Wheat Yield Increase 1987-1997 Kg/ha/yr	Average Wheat Yield 5 years time (2002) t/ha	Expected Wheat Yield Increase (1997-2002) (%)	Expected Wheat Yield Increase (1997-2002) Kg/ha/year
South East	2.28 (N=141)	3.04 (N=158)	38.4 (N=140)	78.2	3.72 (N=135)	20.8 (N=135)	121.8
Mallee	1.19 (N=320)	1.53 (N=335)	32.1 (N=317)	34.3	1.84 (N=290)	20.1 (N=289)	61.1
North	2.00 (N=712)	2.65 (N=727)	33.8 (N=708)	64.4	3.15 (N=622)	17.2 (N=622)	92.2
Yorke Peninsula	2.01 (N=343)	2.69 (N=352)	35.6 (N=340)	67.8	3.12 (N=290)	16.6 (N=289)	86.2
Eyre Peninsula	1.31 (N=622)	1.63 (N=633)	24.9 (N=614)	32.7	1.96 (N=532)	19.4 (N=531)	63.9
State Average	1.70 (N=2219)	2.23 (N=2292)	31.6	52.4	2.65 (N=1940)	18.5	80.6

**APPENDIX L: Frequency of access & usefulness of information sources.**

Information Source	Frequency of Access					Usefulness of Source				
	Never	1 or 2 times/year	3-4 times/year	Monthly	Fortnight	No use	Interest only	Some use	Very useful	Extremely use
<b>Printed media</b>										
Local newspaper	9.4 (n=210)	11.7 (n=261)	10.7 (n=240)	15.9 (n=356)	52.2 (n=1167)	2.2 (n=40)	11.9 (n=218)	64.1 (n=1177)	15.0 (n=276)	6.9 (n=126)
The Stock Journal	1.2 (n=28)	2.2 (n=51)	4.7 (n=108)	10.0 (n=233)	81.9 (n=1901)	0.2 (n=4)	1.5 (n=32)	24.5 (n=509)	41.8 (n=867)	32.0 (n=663)
Ground Cover	23.0 (n=491)	18.0 (n=384)	37.2 (n=795)	17.4 (n=373)	4.4 (n=95)	1.1 (n=16)	6.4 (n=96)	51.6 (n=771)	29.8 (n=445)	11.1 (n=165)
Harvest Report	32.1 (n=672)	34.6 (n=724)	20.6 (n=432)	8.5 (n=179)	4.2 (n=87)	0.3 (n=4)	4.8 (n=62)	33.0 (n=428)	36.1 (n=468)	25.9 (n=336)
<b>Electronic media</b>										
ABC Country Hour	8.7 (n=195)	4.8 (n=108)	8.0 (n=180)	13.9 (n=314)	64.6 (n=1456)	0.4 (n=8)	3.6 (n=67)	33.3 (n=618)	32.4 (n=601)	30.2 (n=580)
The Internet	92.5 n=1920	1.6 (n=34)	1.5 (n=31)	2.5 (n=52)	1.9 (n=39)	4.2 (n=6)	16.1 (n=23)	51.8 (n=74)	18.2 (n=26)	9.8 (n=14)
<b>Personal sources</b>										
Neighbours	3.9 (n=87)	9.4 (n=211)	23.8 (n=535)	32.0 (n=720)	30.9 (n=694)	0 (n=6)	2.2 (n=43)	36.8 (n=716)	37.0 (n=730)	23.2 (n=451)
Family members	12.4 (n=265)	10.6 (n=226)	14.3 (n=307)	20.3 (n=435)	42.4 (n=909)	0.2 (n=4)	3.1 (n=53)	34.5 (n=587)	36.6 (n=623)	25.6 (n=436)
Private Agric Consultant	69.2 n=1476	7.2 (n=154)	7.8 (n=167)	8.5 (n=181)	7.3 (n=155)	1.0 (n=6)	2.0 (n=12)	13.7 (n=83)	31.5 (n=191)	51.9 (n=315)
Chemical reseller	6.3 (n=139)	15.8 (n=349)	35.3 (n=782)	31.4 (n=695)	11.2 (n=249)	0.6 (n=12)	2.4 (n=44)	39.1 (n=731)	40.5 (n=756)	17.4 (n=326)
PIRSA Advisor/ Agronomist	30.4 (n=656)	32.7 (n=705)	26.8 (n=577)	7.6 (n=163)	2.6 (n=56)	0.2 (n=3)	1.9 (n=26)	28.4 (n=386)	45.1 (n=614)	24.4 (n=332)
<b>Participation in groups</b>										
Landcare Group	63.8 n=1403	55.2 (n=439)	32.4 (n=258)	10.8 (n=86)	1.6 (n=13)	1.0 (n=7)	8.2 (n=60)	54.2 (n=397)	29.4 (n=215)	7.2 (n=53)
Right Rotations	43.5 (n=953)	60.2 (n=745)	31.6 (n=391)	6.1 (n=76)	2.1 (n=26)	0.6 (n=7)	2.0 (n=23)	35.3 (n=404)	45.1 (n=517)	17.0 (n=195)
Agricultural Bureau	32.5 (n=718)	27.0 (n=404)	28.1 (n=420)	42.0 (n=628)	2.8 (n=42)	0.3 (n=4)	1.8 (n=25)	32.0 (n=444)	46.1 (n=640)	19.9 (n=276)
TOPCROP group	76.3 n=1625	27.0 (n=136)	48.4 (n=244)	19.8 (n=100)	4.8 (n=24)	0.7 (n=3)	2.2 (n=10)	24.8 (n=115)	44.7 (n=207)	27.7 (n=128)
Chemical reseller discussion group	60.7 n=1309	71.9 (n=608)	22.2 (n=188)	4.4 (n=37)	1.5 (n=13)	0.1 (n=1)	4.5 (n=22)	51.3 (n=391)	38.2 (n=291)	7.5 (n=57)
Property Mgt Planning group	76.9 n=1634	60.7 (n=298)	27.9 (n=137)	9.6 (n=47)	1.8 (n=9)	2.0 (n=9)	8.3 (n=38)	48.0 (n=220)	32.3 (n=148)	2.3 (n=43)
<b>Attendance at Field Days*</b>										
Ag. Bureau Field Days	35.6 (n=790)					0 (n=1)	0.6 (n=8)	24.9 (n=314)	49.5 (n=625)	25.7 (n=315)
Ag. Bureau Conferences	64.3 n=1389					0.2 (n=1)	2.6 (n=17)	35.9 (n=239)	45.2 (n=301)	16.2 (n=108)
Stubble Handling Field Day	37.8 n=836					0.2 (n=2)	2.1 (n=25)	40.5 (n=480)	43.1 (n=511)	14.2 (n=168)
Eyre Peninsula Field Days	48.0 n=1062					0.1 (n=1)	1.9 (n=18)	28.7 (n=278)	41.6 (n=403)	27.8 (n=269)
GRDC Ag Expo	84.3 n=1778					1.1 (n=3)	2.6 (n=7)	24.3 (n=66)	45.6 (n=124)	26.5 (n=72)

\*Information sought related to either usually attended, or never attended, most field days occurring on an annual or biennial basis.

## APPENDIX L: Frequency of access & usefulness of information sources.

Information Source	Frequency of Access					Usefulness of Source				
	Never	1 or 2 times/yr	3-4 times/yr	Monthly	Fortnight	No use	Interest only	Some use	Very useful	Extremely use
<b>Printed media</b>										
Local newspaper	9.4 (n=210)	11.7 (n=261)	10.7 (n=240)	15.9 (n=356)	52.2 (n=1167)	2.2 (n=40)	11.9 (n=218)	64.1 (n=1177)	15.0 (n=276)	6.9 (n=126)
The Stock Journal	1.2 (n=28)	2.2 (n=51)	4.7 (n=108)	10.0 (n=233)	81.9 (n=1901)	0.2 (n=4)	1.5 (n=32)	24.5 (n=509)	41.8 (n=867)	32.0 (n=663)
Ground Cover	23.0 (n=491)	18.0 (n=384)	37.2 (n=795)	17.4 (n=373)	4.4 (n=95)	1.1 (n=16)	6.4 (n=96)	51.6 (n=771)	29.8 (n=445)	11.1 (n=165)
Harvest Report	32.1 (n=672)	34.6 (n=724)	20.6 (n=432)	8.5 (n=179)	4.2 (n=87)	0.3 (n=4)	4.8 (n=62)	33.0 (n=428)	36.1 (n=468)	25.9 (n=336)
<b>Electronic media</b>										
ABC Country Hour	8.7 (n=195)	4.8 (n=108)	8.0 (n=180)	13.9 (n=314)	64.6 (n=1456)	0.4 (n=8)	3.6 (n=67)	33.3 (n=618)	32.4 (n=601)	30.2 (n=560)
The Internet	92.5 n=1920	1.6 (n=34)	1.5 (n=31)	2.5 (n=52)	1.9 (n=39)	4.2 (n=6)	16.1 (n=23)	51.8 (n=74)	18.2 (n=26)	9.8 (n=14)
<b>Personal sources</b>										
Neighbours	3.9 (n=87)	9.4 (n=211)	23.8 (n=535)	32.0 (n=720)	30.9 (n=694)	0 (n=6)	2.2 (n=43)	36.8 (n=716)	37.0 (n=730)	23.2 (n=451)
Family members	12.4 (n=265)	10.6 (n=226)	14.3 (n=307)	20.3 (n=435)	42.4 (n=909)	0.2 (n=4)	3.1 (n=53)	34.5 (n=587)	36.6 (n=623)	25.6 (n=436)
Private Agric Consultant	69.2 n=1476	7.2 (n=154)	7.8 (n=167)	8.5 (n=181)	7.3 (n=155)	1.0 (n=6)	2.0 (n=12)	13.7 (n=83)	31.5 (n=191)	51.9 (n=315)
Chemical reseller	6.3 (n=139)	15.8 (n=349)	35.3 (n=782)	31.4 (n=695)	11.2 (n=249)	0.6 (n=12)	2.4 (n=44)	39.1 (n=731)	40.5 (n=756)	17.4 (n=326)
PIRSA Advisor/ Agronomist	30.4 (n=656)	32.7 (n=705)	26.8 (n=577)	7.6 (n=163)	2.6 (n=56)	0.2 (n=3)	1.9 (n=26)	28.4 (n=386)	45.1 (n=614)	24.4 (n=332)
<b>Participation in groups</b>										
Landcare Group	63.8 n=1403	55.2 (n=439)	32.4 (n=258)	10.8 (n=86)	1.6 (n=13)	1.0 (n=7)	8.2 (n=60)	54.2 (n=397)	29.4 (n=215)	7.2 (n=53)
Right Rotations	43.5 (n=953)	60.2 (n=745)	31.6 (n=391)	6.1 (n=76)	2.1 (n=26)	0.6 (n=7)	2.0 (n=23)	35.3 (n=404)	45.1 (n=517)	17.0 (n=195)
Agricultural Bureau	32.5 (n=718)	27.0 (n=404)	28.1 (n=420)	42.0 (n=628)	2.8 (n=42)	0.3 (n=4)	1.8 (n=25)	32.0 (n=444)	46.1 (n=640)	19.9 (n=276)
TOPCROP group	76.3 n=1625	27.0 (n=136)	48.4 (n=244)	19.8 (n=100)	4.8 (n=24)	0.7 (n=3)	2.2 (n=10)	24.8 (n=115)	44.7 (n=207)	27.7 (n=128)
Chemical reseller group	60.7 n=1309	71.9 (n=608)	22.2 (n=188)	4.4 (n=37)	1.5 (n=13)	0.1 (n=1)	4.5 (n=22)	51.3 (n=391)	38.2 (n=291)	7.5 (n=57)
Property Mgt Planning group	76.9 n=1634	60.7 (n=298)	27.9 (n=137)	9.6 (n=47)	1.8 (n=9)	2.0 (n=9)	8.3 (n=38)	48.0 (n=220)	32.3 (n=148)	2.3 (n=43)
<b>Attendance at Field Days*</b>										
Ag. Bureau Field Days	35.6 (n=790)					0 (n=1)	0.6 (n=8)	24.9 (n=314)	49.5 (n=625)	25.7 (n=315)
Ag. Bureau Conferences	64.3 n=1389					0.2 (n=1)	2.6 (n=17)	35.9 (n=239)	45.2 (n=301)	16.2 (n=108)
Stubble Handling Field Day	37.8 n=836					0.2 (n=2)	2.1 (n=25)	40.5 (n=480)	43.1 (n=511)	14.2 (n=168)
Eyre Peninsula Field Days	48.0 n=1062					0.1 (n=1)	1.9 (n=18)	28.7 (n=278)	41.6 (n=403)	27.8 (n=269)
GRDC Ag Expo	84.3 n=1778					1.1 (n=3)	2.6 (n=7)	24.3 (n=66)	45.6 (n=124)	26.5 (n=72)

\*Information sought related to either usually attended, or never attended, most field days occurring on an annual or biennial basis.

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## APPENDIX M:

Respondents who cited specific information sources as being the most influential, in their decision to try the new technology (expressed as a percentage of total respondents who cited various information sources for each specific technology example)

Information Source Technology example	PIRSA	Agribusiness	Agricultural Consultants	Agricultural Bureau	Field Days and seminars	Farmers	Media (electronic)	Publications	Stock Journal	Educational Institutions	Marketing Authorities	Callum Downs	Fertiliser representatives	Kondinin Farming group	Other
Wheat Protein Management (n=709)	18.6	4.7	5.1	10.4	12.1	24.7	1.3	5.6	2.3	0.6	3.0	0	0	0	11.7
Disease ID and control (n=785)	27.0	2.2	5.5	13.4	8.5	19.1	1.3	5.0	2.4	1.3	0	0	0	0	14.4
Grain Marketing & Risk Mgt (n=334)	1.8	2.4	11.7	0.9	3.6	12.3	2.4	6.9	8.1	1.8	20.4	19.8	0	0	7.5
Zinc Nutrition program (n=717)	16.9	3.4	7.5	3.5	24.7	13.1	1.4	2.1	1.4	0	0	0	17.3	0	8.8
Herbicide Resistance Management program (n=604)	20.2	16.7	7.3	5.8	9.4	12.6	2.2	6.5	3.0	0	0	0	0	0	16.4
Canola Production (n=206)	23.4	6.3	12.6	0.5	5.8	25.2	0	12.6	0.5	0	0	0	0	0	11.7
Yield Mapping technologies (n=9)	0	0	0	0	11.0	34.0	0	55.0	0	0	0	0	0	0	0
Climatic Yield Risk Management Service (n=24)	20.8	4.2	0	4.2	12.5	16.7	0	0	4.2	0	0	0	0	33.3	8.3
Frame wheat (n=980)	15.5	2.9	4.8	3.2	19.2	33.3	1.1	5.5	3.5	0	4.7	0	0	0	6.5
Crop Monitoring program (n=1196)	25.0	6.1	10.1	13.4	4.6	21.5	0.7	4.1	1.9	1.9	0	0	0	0	10.7
Minimum tillage program (n=1107)	10.8	6.7	3.3	3.8	10.6	36.1	2.1	8.5	3.9	0	0	0	0	0	14.1
Average Value (%)	18.2	5.6	6.7	7.1	11.5	23.7	1.4	5.7	2.9	0.7	2.0	1.0	1.9	0.8	11.3



## APPENDIX N: Adoption rates for best practice (respondents who always practice)

Farming practice	(% Adoption rate of those who "always practice"					State average
	South East	Mallee	North	Yorke Peninsula	Eyre Peninsula	
1. Gross margin planning	40.1 (n=167)	28.6 (n=343)	32.7 (n=732)	26.1 (n=364)	31.3 (n=639)	31.2 (n=2257)
2. Grain marketing plan	27.0 (n=167)	18.6 (n=350)	20.5 (n=732)	19.9 (n=356)	11.5 (n=646)	18.0 (n=2264)
3. Rotations using resistant varieties	70.1 (n=167)	66.7 (n=352)	77.5 (n=751)	87.6 (n=370)	65.5 (n=656)	73.5 (n=2309)
4. Soil test for fertility	38.3 (n=167)	17.6 (n=352)	34.4 (n=751)	26.2 (n=370)	32.6 (n=656)	30.3 (n=2309)
5. Grade and apply dressings to seed	88.0 (n=166)	91.8 (n=355)	93.1 (n=751)	94.4 (n=372)	89.5 (n=659)	91.7 (n=2316)
6. Fungicidal seed dressings on barley	67.5 (n=166)	56.7 (n=349)	64.9 (n=746)	68.1 (n=367)	53.9 (n=644)	61.1 (n=2285)
7. Adjust seed rates to seed size & conditions	62.5 (n=168)	68.5 (n=355)	60.1 (n=749)	55.4 (n=370)	58.3 (n=660)	60.3 (n=2315)
8. Cultivate dry soils	3.0 (n=166)	4.6 (n=352)	1.5 (n=751)	3.0 (n=368)	7.3 (n=657)	4.0 (n=2307)
9. Burn stubbles	8.3 (n=169)	1.1 (n=350)	2.7 (n=749)	4.9 (n=371)	2.3 (n=658)	3.1 (n=2310)
10. Knock-down herbicides prior sowing	46.3 (n=164)	17.8 (n=355)	35.8 (n=749)	32.8 (n=372)	43.6 (n=661)	35.5 (n=2314)
11. Fertiliser rates adjusted to target yield & fertility	54.8 (n=168)	37.4 (n=353)	52.7 (n=752)	51.5 (n=373)	34.6 (n=661)	45.2 (n=2320)
12. Narrow points on seeding equipment	31.7 (n=167)	10.1 (n=355)	26.6 (n=745)	17.8 (n=365)	13.4 (n=659)	19.3 (n=2304)
13. Monitor weeds prior to herbicide selection	92.8 (n=167)	77.3 (n=352)	87.4 (n=752)	87.8 (n=371)	82.4 (n=659)	85.2 (n=2315)
14. Tissue test crops for trace elements	17.3 (n=168)	6.9 (n=349)	6.9 (n=745)	6.7 (n=371)	18.7 (n=659)	10.9 (n=2305)
15. Sow medic pastures	26.1 (n=165)	13.4 (n=351)	25.8 (n=744)	34.4 (n=369)	17.1 (n=655)	22.8 (n=2297)
16. Control red legged earth mite in pastures	47.6 (n=166)	10.5 (n=353)	39.7 (n=745)	42.1 (n=371)	12.7 (n=652)	28.5 (n=2300)
17. Spray-graze pastures for broad leaf weeds	17.4 (n=167)	13.0 (n=355)	17.7 (n=751)	18.6 (n=371)	16.7 (n=658)	16.7 (n=2315)
18. Spray pastures with a selective grass herbicide	4.2 (n=166)	7.4 (n=353)	12.7 (n=747)	16.8 (n=370)	12.0 (n=656)	11.7 (n=2305)
19. "Spray top" pastures for grass control in spring	32.7 (n=168)	42.8 (n=353)	42.5 (n=748)	55.4 (n=372)	58.6 (n=660)	48.4 (n=2314)
20. Rotate herbicide groups to avoid resistance	51.5 (n=165)	29.9 (n=354)	56.3 (n=749)	57.9 (n=373)	44.7 (n=658)	48.7 (n=2312)
21. Broadcast fertiliser onto pastures	51.5 (n=167)	4.0 (n=351)	16.8 (n=744)	27.7 (n=372)	6.0 (n=652)	16.2 (n=2299)
22. Green manure legume crops and pastures	1.2 (n=163)	2.6 (n=352)	2.9 (n=751)	1.9 (n=371)	1.1 (n=655)	2.0 (n=2305)
23. Long fallow (cultivate usually before October)	1.2 (n=83.2)	14.4 (n=355)	0 (n=755)	1.4 (n=370)	1.7 (n=657)	3.9 (n=2315)
24. Insure majority of crop for hail / fire	81.1 (n=169)	82.5 (n=355)	88.7 (n=753)	89.3 (n=374)	91.5 (n=660)	88.1 (n=2324)
25. Inspect grain storage for insect pests	78.4 (n=167)	86.7 (n=354)	77.5 (n=751)	83.9 (n=372)	80.2 (n=658)	80.1 (n=2315)
26. Conduct on-farm trials and comparisons	18.8 (n=165)	21.1 (n=351)	17.8 (n=752)	18.8 (n=373)	20.4 (n=657)	19.3 (n=2311)
27. Replace old cereal seed with certified as required	40.5 (n=168)	38.9 (n=355)	42.7 (n=755)	51.7 (n=373)	47.3 (n=662)	44.7 (n=2326)

## APPENDIX O: Awareness and adoption of innovations

Innovation	Adoption characteristics				
	% who are aware	% who have tried technology	% continuing (of those who have tried it)	Rate of dis-adoption	Time lag to adoption (days)
Minimum tillage	96.0 (n=2179)	75.0 (n=1598)	92.8 (n=1478)	7.2 (n=115)	1302 (n=1169)
Crop monitoring	92.1 (n=2028)	81.3 (n=1584)	94.5 (n=1465)	5.5 (n=85)	452 (n=1130)
Wheat protein management	94.7 (n=1054)	87.6 (n=910)	96.3 (n=275)	3.7 (n=33)	719 (n=678)
Disease identification and control	93.5 (n=1087)	92.4 (n=974)	98.2 (n=945)	1.8 (n=17)	633 (n=743)
Grain marketing and risk management	91.3 (n=973)	49.1 (n=468)	78.1 (n=364)	21.9 (n=102)	572 (n=367)
Zinc nutrition program	92.6 (n=1070)	81.4 (n=855)	89.3 (n=753)	10.7 (n=90)	608 (n=735)
Herbicide resistance management	92.8 (n=1016)	75.9 (n=749)	98.6 (n=729)	1.4 (n=10)	551 (n=539)
Canola production	84.1 (n=886)	31.3 (n=272)	87.9 (n=233)	12.1 (n=32)	1354 (n=248)
Yield mapping technologies	83.3 (n=871)	1.3 (n=11)	90.9 (n=10)	9.1 (n=1)	284 (n=9)
Climatic yield and risk management	45.2 (n=419)	10.6 (n=42)	51.2 (n=21)	48.8 (n=20)	1452 (n=38)
Growing Frame wheat	96.2 (n=2228)	62.5 (n=1374)	90.9 (n=1237)	9.1 (n=124)	462 (n=1167)

## Appendix P: Reasons cited for continued adoption of practices

Practice Example	Reasons cited for continued adoption										
	Yield & quality	Economic	Agronomic	Improve management	Evaluating	Proven technology	Disease / resistance control	Info gained	Risk mgt	Soil and land	other
Wheat protein mgt (n=1222)	36.3 (n=444)	19.5 (n=238)	13.2 (n=161)	3.3 (n=40)	2.5 (n=31)	20.4 (n=249)	4.0 (n=49)	0	0	0	0.8 (n=1)
Disease id and mgt (n=1191)	23.0 (n=274)	11.5 (n=137)	16.3 (n=194)	5.7 (n=68)	2.4 (n=28)	23.0 (n=274)	13.4 (n=159)	4.0 (n=47)	0	0	0.8 (n=10)
Grain Marketing (n=401)	0	53.9 (n=216)	0	7.7 (n=31)	10.5 (n=42)	0	0	8.5 (n=34)	17.0 (n=68)	0	2.5 (n=10)
Zinc nutrition (n=798)	22.1 (n=176)	3.6 (n=29)	41.6 (n=332)	5.6 (n=45)	14.9 (n=119)	11.0 (n=88)	0	0.8 (n=6)	0	0	0.4 (n=3)
Herbicide resistance (n=874)	2.9 (n=25)	3.8 (n=33)	18.4 (n=161)	20.4 (n=171)	0.7 (n=6)	7.0 (n=61)	45.8 (n=400)	0.1 (n=1)	0	0	1.0 (n=9)
Growing canola (n=316)	3.8 (n=12)	19.9 (n=63)	8.3 (n=26)	6.7 (n=21)	15.5 (n=49)	3.5 (n=11)	41.8 (n=132)	0	0	0	0.7 (n=n=)
Yield mapping (n=10)	10 (n=1)	0	0	30 (n=3)	20 (n=2)	0	0	40 (4)	0	0	0
Climatic yield / risk info service (n=22)	0	9.1 (n=2)	0	27.3 (n=6)	0	0	0	27.3 (n=6)	0	0	36.4 (n=)
Growing "frame" wheat (n=1821)	31.3 (n=570)	0.8 (n=14)	10.3 (n=187)	0	9.1 (n=166)	0	35.8 (n=651)	0	2.3 (n=42)	0	0.4 (n=7)
Crop monitoring (n=1848)	14.8 (n=273)	13.3 (n=245)	12.1 (n=224)	13.5 (n=250)	5.0 (n=93)	20.6 (n=381)	0	19.6 (n=362)	0	0	1.1 (n=20)
Minimum tillage (n=2335)	5.5 (n=128)	9.8 (n=229)	19.8 (n=459)	1.1 (n=26)	5.9 (n=137)	11.7 (n=274)	0	0	0	40.7 (n=951)	0.9 (n=22)
% of total	17.6	11.1	16.1	6.2	6.2	12.4	9.1	4.2	1.0	8.8	0.9
Total (n=10838)	1903	1206	1518	668	673	1338	1391	460	110	951	101

## Appendix Q: Reasons for not implementing specific technologies

Specific technology example	Reason for not trying the innovation										
	No perceived need	Cost benefit	Agronomic	Time	Not suited	Lack knowledge	Considering	Small operation	Do not use herbicides	No suitable equipment	Other
Wheat protein management (n=136)	11.0 (n=16)	22.1 (n=30)	12.5 (n=17)	2.2 (n=3)	40.4 (n=55)	2.2 (n=3)	5.9 (n=8)	0	0	0	2.9 (n=4)
Disease identification and management (n=56)	23.2 (n=13)	3.6 (n=2)	0	16.1 (n=9)	12.5 (n=7)	0	25.0 (n=14)	0	0	0	19.6 (n=11)
Grain marketing (n=479)	24.4 (n=117)	3.5 (n=17)	0	4.8 (n=23)	12.9 (n=62)	37.8 (n=181)	2.5 (n=12)	13.2 (n=63)	0	0	0.8 (n=4)
Zinc nutrition (n=161)	35.4 (n=57)	18.6 (n=30)	0.6 (n=1)	5.0 (n=8)	21.7 (n=35)	3.1 (n=5)	14.3 (n=23)	0	0	0	1.2 (n=2)
Herbicide resistance (n=232)	71.6 (n=166)	2.2 (n=5)	1.3 (n=3)	0.4 (n=1)	3.0 (n=7)	0.9 (n=2)	5.6 (n=13)	0	14.7 (n=34)	0	0.4 (n=1)
Growing canola (n=653)	4.1 (n=27)	17.6 (n=115)	12.1 (n=79)	1.8 (n=12)	42.6 (n=278)	4.4 (n=29)	4.3 (n=28)	0	0	10.3 (n=67)	2.8 (n=18)
Yield mapping (n=938)	8.0 (n=75)	54.6 (n=512)	1.9 (n=18)	1.8 (n=17)	12.5 (n=117)	5.8 (n=54)	2.4 (n=22)	5.8 (n=54)	0	5.2 (n=49)	2.1 (n=20)
Climatic yield / risk info service (n=287)	26.8 (n=77)	11.8 (n=34)	1.4 (n=4)	5.3 (n=15)	38.0 (n=109)	7.7 (n=22)	3.5 (n=10)	0	0	4.5 (n=13)	1.1 (n=3)
Growing "Frame" wheat (n=680)	45.7 (n=311)	0.6 (n=4)	16.9 (n=115)	0.6 (n=4)	17.2 (n=117)	6.5 (n=44)	11.3 (n=77)	0	0	0	1.2 (n=8)
Crop monitoring (n=233)	17.2 (n=40)	6.4 (n=15)	1.3 (n=3)	30.0 (n=70)	7.3 (n=17)	8.2 (n=19)	25.3 (n=59)	0	0	0	4.3 (n=10)
Minimum tillage (n=568)	4.4 (n=25)	18.7 (n=106)	9.9 (n=56)	0.2 (n=1)	34.3 (n=195)	1.8 (n=10)	6.5 (n=37)	0	4.6 (n=26)	18.5 (n=105)	1.2 (n=7)
% of total	20.9	19.7	6.7	3.7	22.6	8.3	6.8	2.7	1.4	5.3	0.8

## Appendix R: Reasons for dis-adoption of technologies

Specific technology example	Reason for dis-adoption of technologies								
	No benefit	Difficult to implement	Not suited	Still evaluating	Agronomic factors	Poor servicing	Machinery	Time	Other
Wheat protein management (n=37)	59.5 (n=22)	13.5 (n=5)	10.8 (n=4)	0	0	0	0	0	16.2 (n=6)
Disease identification and management (n=22)	13.6 (n=3)	36.4 (n=8)	0	9.1 (n=2)	0	0	0	0	41.0 (n=9)
Grain marketing (n=140)	48.6 (n=68)	25.7 (n=36)	0	0	16.4 (n=23)	0	0	0	9.3 (n=13)
Zinc nutrition (n=97)	67.0 (n=65)	4.1 (n=4)	20.6 (n=20)	0	0	0	0	2.1 (n=2)	6.2 (n=6)
Herbicide resistance (n=13)	53.8 (n=7)	38.5 (n=5)	0	0	0	0	0	0	7.7 (n=1)
Growing canola (n=50)	28.0 (n=14)	36.0 (n=18)	12.0 (n=24)	2.5 (n=5)	0	0	0	0	0.5 (n=1)
Yield mapping (n=3)	0.33 (n=1)	0	0	0.33 (n=1)	0	0	0	0	0.33 (n=1)
Climatic yield / risk information service (n=23)	26.1 (n=6)	0	13.0 (n=3)	0	0	39.1 (n=9)	0	0	17.4 (n=4)
Growing Frame wheat (n=162)	39.5 (n=64)	14.2 (n=23)	16.7 (n=27)	0	26.6 (n=43)	0	0	0	3.1 (n=5)
Crop monitoring (n=90)	23.3 (n=21)	24.4 (n=22)	0	10 (n=9)	0	7.8 (n=7)	0	22.2 (n=20)	12.2 (n=11)
Minimum tillage (n=176)	26.7 (n=47)	42.6 (n=75)	13.6 (n=24)	8.5 (n=15)	0	0	7.4 (n=13)	0	1.1 (n=2)
% of total	38.7	22.7	12.4	3.8	8.0	0.2	0.2	0.3	8.2
Total (n=825)	320	187	102	31	66	16	13	22	68

APPENDIX S: Correlation Analysis of Selected Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
1.Age (categorical)	1	-0.31	0.74																	-0.96					-0.27	-0.21		
2.Education	-0.31	1	-0.29																							0.29		
3.Years involved managing farm	0.74	-0.29	1					0.2																		-0.22	-0.2	
4.Growing Season Rainfall				1	0.30	0.21							0.70	0.68	-0.34	-0.2				-0.2		0.21						
5.Total Market value of farm				0.3	1	0.48	0.58						0.43	0.23	0.28	0.31			0.37					0.21				
6.Total value of farm debt				0.21	0.48	1	0.31	-0.60					0.23						0.2									
7.Total value of farm machinery					0.58	0.31	1				0.2				0.39	0.5			0.48									
8.Equity in the farm business			0.2			-0.6		1																				
9.Printed info source access										1	0.35	0.44	0.33							0.21	0.23		0.24	0.2	0.28	0.27		
10.Electronic info source access										0.35	1	0.33	0.21															
11.Personal info source access							0.2			0.44	0.33	1	0.29							0.21		0.24		0.29				
12.Group based participation										0.33	0.21	0.29	1							0.21	0.29		0.27	0.26	0.25	0.33	0.21	0.23
13.Wheat yields (nowadays) t/ha				0.7	0.43	0.23							1	0.53	-0.4			0.35		0.3		0.2		0.29	0.22			
14.% potential wheat yield (97)				0.68	0.23								0.53	1				0.24										
15.Total arable area				-0.34	0.28		0.39						-0.4		1				0.34									
16.Total area in crop (1997, ha)					0.31		0.5						-0.2		0.65	1			0.81									
17.Cropping intensity of farm													0.35	0.24				1	0.3	0.26				0.25				
18.Total t of wheat and barley					0.37	0.2	0.48								0.34	0.81	0.3		1					0.21				
19.Crop establishment adoption				-0.2						0.21		0.21	0.3					0.26		1	0.35	0.33	0.31	0.33	0.46	0.27		
20.Crop nutrition adoption	-0.96									0.23		0.21	0.29							0.35	1	0.47	0.32	0.34	0.35	0.27		
21.Weed/pest mgt adoption													0.2							0.33	0.47	1	0.26	0.28	0.38			
22.Grain marketing adoption				0.21						0.24		0.24	0.27							0.31	0.32	0.26	1	0.44	0.41	0.32		
23.Mgt of risk and rotations										0.2		0.26								0.33	0.34	0.28	0.44	1	0.4	0.32		
24.No. innovtns "always used"					0.21					0.28		0.29	0.25	0.29						0.25	0.21	0.46	0.35	0.38	0.41	0.4	1	0.3
25.Innovativeness (score)	-0.27	0.29	-0.22							0.27		0.33	0.22							0.3	0.27		0.32	0.32	0.3	1		
26.Soil erosion	-0.21		-0.2									0.21															1	0.44
27.Soil fertility												0.23														0.21	0.44	1

Pearson's Correlation co-efficients Prob>R, P=0.0001, values > than or equal to +/- 0.20 presented

## APPENDIX T: Summary of key results from the study

Characteristic	Key outcome / result	Comments and interpretation
Personal characteristics	<b>Age;</b> Average age was in the 40-49 year category	Farmer age is distributed relatively evenly across the categories, the most dominant range being the 40-49 year age category
	<b>Education;</b> 42.5% completed part of secondary schooling, 6.4% having tertiary qualifications	Respondents had relatively low levels of education, few having professional qualifications
	<b>Farming experience;</b> 71.6% of respondents had greater than 10 years farming experience	The survey audience are well experienced in relation to farming
	<b>Farm family ownership;</b> 67.9% of respondents have had the farm property held in their family for >30 years	Farm family ownership is characterised by relatively stable ownership patterns, with a relatively long family history of ownership
	<b>Attitude to technology and innovation;</b> 46% respondents agree to the statement "I regard myself as a fairly traditional and conservative farmer"	The farming population represented in the survey remain very traditional and conservative
	<b>Attitude to crop improvement potential;</b> 72% respondents agree to the statement "there is significant opportunity to increase crop yields on my farm"	The farming population recognise that there is the potential to increase crop yields and general productivity
	<b>Decision-making processes;</b> 95.9% of respondents consult with others prior to making management/operational decisions	A wide degree of consultation relating to decision-making occurs, but some work in isolation, particularly on Eyre Peninsula
	<b>Quartile comparisons for the characteristic 'innovativeness'</b> characteristics compared between the 'top 25%' (innovative) with the 'bottom 25%' (conservative) respondents. The top 25% quartile; 'innovative farmers' were found to be significantly younger, though having less farming experience than the 'conservative farmers', and were willing to take more risks. Innovative farmers accessed information and participated in group activities more so than conservative farmers.  'Conservative farmers' had a significantly lower 'land stewardship score' and were more concerned about their 'long-term financial viability'. 'Conservative farmers' had slightly higher equity levels, and significantly lower debt levels and farm value and farmed in environments receiving slightly less growing season rainfall.  There was no difference in farm area between the two groups, although 'innovative farmers' had significantly greater crop area, sowing intensity, grain production and area sown to broad leaf crop. 'Conservative farmers' had significantly lower levels of adoption, as well as access to information sources and participation at field days and group based activities.	Innovative farmers had a number of characteristics different to those of the 'innovative farmers'. The analysis identified statistically significant differences between the two quartiles.  The main differences relating to age, level of information access, adoption of practices, debt level and farming intensity.  It is evident that the innovative farmers are prepared to take greater risks (conservative farmers having a greater risk aversion; and slightly less annual rainfall). It is interesting to note that there are no significant differences in farm area.
<p><b>Implications associated with Personal Characteristics</b></p> <p>The personal characteristics have provided an overview of the personal profile of the 'average' farmer in the research audience. The average farmer is conservative in attitude towards innovation, undertake shared decision-making processes and believe that improvements in crop productivity are possible. There are differences in the population in terms of comparing farmers (quartile comparisons) on the basis of the variable 'innovativeness', with significant differences in a range of variables relating to productivity, adoption of practices, financial performance, risk aversion and accessing of information / participation in extension based group activities.</p> <p><b><i>This has implications in developing strategies for extension, in terms of being aware of the personal characteristics of the research audience, and the differences in characteristics of the respondents, particularly as they relate to conservatism and innovativeness.</i></b></p>		

APPENDIX T continued

Characteristic	Key outcome / result	Comments and interpretation
<b>Situational characteristics</b>	<b>Rainfall</b> ; majority of respondents (47.5%) farm in the 351-450mm rainfall zone, however 41% receive 350mm rainfall or less.	Grain production is undertaken in a relatively low rainfall environment, however there are regional differences receiving similar growing season rainfall and having different levels of yield potential achievement.
	<b>Land management concerns</b> ; of greatest problem/threat were wind erosion (33.8%), soil organic matter decline (21.4%) and non-wetting sands (20.9% of all respondents).	Farmers are aware of, and concerned in relation to a range of land management issues
	<b>Farm area</b> ; 51.5% of respondents have a farm area of 501-1500 ha.	Farm area also varies according to the specific region, with the largest of property sizes being located on Eyre Peninsula.
	<b>Farm equity</b> ; average farm equity is 85.8%. Some 12.8% of respondents had equity levels of 65% or less.	Whilst the overall farm equity can be considered satisfactory, it is of concern that 12.8% of the population had equity levels of less than 65%.
	<b>Confidence in long-term future</b> ; 38.6% have varying "degrees of concern"	Many farmers are concerned about their long-term future.
	<b>Average wheat yield</b> across all respondents ranged from 1.53 t/ha (Mallee region) to 3.04 t/ha (South East region), with the average yield for all being 2.23 t/ha	There are significant differences in the average wheat yields achieved across the State, reflective of variability in rainfall and soil type.
	<b>Grain production deciles</b> ; 1.8% of farmers are responsible for 10% of total production, 27.8% farmers are responsible for 10% of total production	There are marked differences in the productive capacity of farmers, with the decile production figures indicating large differences in the overall production levels.
	<b>Quartile comparisons for crop yield potential achieved</b> were undertaken, comparing the 'top 25%' with the 'bottom 25%' of yields achieved.  "High yield achievers" had greater equity in their farm business, with significantly higher property values, less growing season rainfall, and less arable cropping area. 'High yield achievers' attained an average crop yield potential of 81.2%, in comparison to 37.7% for 'low yield achievers'. Both groups had no significant difference in crop area, however 'high yield achievers' had significantly higher cropping intensity (68.7% of total arable area under crop in comparison to 52.9%).  'High yield achievers' produced significantly more grain per annum, 1681 tonnes in comparison to 1011 tonnes and significantly higher levels of adoption of cropping practices. 'High yield achievers' had significantly higher levels of access and participation to printed information, group activities and field day attendance.	It is evident that those respondents whom were in the top quartile of yield achievement can be perceived as being 'more successful' in overall productivity and business profitability.
<b>Implications associated with Situational Characteristics</b>		
<p>The situational characteristics sought to gather information relating to the environment in which the respondents adopt new technology, and conduct their business of farming. Results indicate that there is variability across the population in terms of annual rainfall, relative productivity and the production capacity of farmers in the survey population. Quartile comparisons in terms of crop yield potential achieved (based upon growing season rainfall) likewise indicates significant differences in terms of production achieved, for example the bottom 25% of 'yield potential achieved' produce on average 1011 tonnes of grain, compared with the top 25% who produce on average 1681 tonnes of grain.</p> <p><b><i>This information is extremely valuable, in terms of generating a far greater understanding of the variability that is evident within the survey population. In terms of developing extension program delivery strategies, it is important to note that not all farmers/farm businesses are alike. Their relative productivity, and yield potential achieved is indicative of different levels of personal ability and 'productive capacity' to produce grain. An understanding of this will emphasise the need to develop tailored and targeted extension messages and programs, rather than taking the approach of 'one size fits all' to developing extension program delivery systems.</i></b></p>		

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Characteristic	Key outcome / result	Comments and interpretation
<b>Relationships between personal and situational characteristics</b>	<p>It is evident that there are <b>links between personal and situational characteristics</b>; "length of farm ownership" of the property was positively associated with "equity levels" (<math>r = 0.27, p &lt; 0.0001</math>). "number of years involved in farming" was inversely associated with "level of education" (<math>r = -0.38, p &lt; 0.001</math>). "Rainfall" was positively associated with "crop yield (wheat)" (<math>r = 0.68, p &lt; 0.0001</math>), and inversely related to "grain protein" (<math>r = -0.44, p &lt; 0.0001</math>). "Crop area sown" was positively associated with "value of machinery" (<math>r = 0.39, p &lt; 0.001</math>).</p>	<p>It is evident that those who had owned their properties for a longer period of time had higher levels of equity in their business, reflecting the ideology that you are 'born into farming', and the difficulty for those trying to enter the industry.</p> <p>Those who had been involved in farming for longer periods had lower levels of education. In terms of the farming environment, wheat crop yields were positively associated with growing season rainfall, and <u>inversely related to grain protein levels</u>.</p>
	<p><b>Conservative and traditional farmers</b> had a number of positive relationships with; "would not try a new chemical until it was well proven" (<math>r = 0.49, p &lt; 0.0001</math>), "age" (<math>r = 0.26, p &lt; 0.0001</math>), whilst being negatively associated with; "outlook on farming" (<math>r = -0.68, p &lt; 0.0001</math>), "number of innovations tried" (<math>r = -0.46, p &lt; 0.0001</math>), "number of information sources" (<math>r = -0.32, p &lt; 0.0001</math>), "level of education achieved" (<math>r = -0.29, p &lt; 0.0001</math>), and "group involvement" (<math>r = -0.26, p &lt; 0.0001</math>).</p>	<p>This is indicative of the conservative approach to new farming practices and technologies held by such farmers. It is evident that those farmers who consider themselves conservative, had lower levels of education, reduced access to a range of information sources, and lower participation in group activities. Conservatism tended to increase with age. Those with high conservatism scores did not adopt many of the new technologies, and accessed few information sources. The 'conservative' characteristic represents a major barrier to the uptake of new farming practices.</p>
<b>Implications associated with relationships between personal and situational characteristics</b>		
<p>It is evident that there are a number of significant relationships between personal and situational characteristics. Length of farm ownership for example, was associated with higher levels of business equity, older farmers tending to have lower levels of education. 'Conservative farmers' were characterised by lower levels of education, and less access to group extension and information sources, and the level of conservatism tended to increase with the age of respondents.</p> <p><i>It is evident that there are a number of significant relationships between personal and situational characteristics. Length of farm ownership for example, was associated with higher levels of business equity, older farmers tending to have lower levels of education. 'Innovative farmers' were characterised by higher levels of education, and greater access to group extension and information sources. As a result, there may be a preferred option to target those farmers who consider themselves 'innovative' in nature in a program aimed at introducing significant change on-farm may be a preferred option. By having an understanding of the audience, and the key outcomes to be achieved, it may be possible to better target specific programs, and the context in which the extension program is to be delivered. If for example conservative farmers are characterised by low information access scores, then creating an awareness of a new practice may be difficult in the first instance.</i></p>		
<b>Best practice relationships</b>	<p>From the data, it is evident that there are specific <b>relationships between the nature of the practices</b> undertaken, and the link to other practices.</p> <p>For example, the practice of long fallowing; "Long fallow" was positively associated with "cultivation dry soils" (<math>r = 0.24, p &lt; 0.0001</math>), "area sown to rye" (<math>r = 0.29, p &lt; 0.0001</math>), with negative relationships with "rainfall" (<math>r = -0.33, p &lt; 0.0001</math>), and "wheat yield" (<math>r = -0.23, p &lt; 0.0001</math>).</p> <p>The practice of "selective grass herbicide use" was positively linked to a range of variables, including "red legged earth mite control" (<math>r = 0.29, p &lt; 0.0001</math>), "sow medic pastures" (<math>r = 0.29, p &lt; 0.0001</math>), "spray graze pastures" (<math>r = 0.28, p &lt; 0.0001</math>), "spray top pastures" (<math>r = 0.27, p &lt; 0.0001</math>) and "rotate herbicide groups" (<math>r = 0.23, p &lt; 0.0001</math>).</p>	<p>The range of 'best practices' tend to be linked to one another, as a result it is possible to predict the behaviour of respondents. Such practices tend to be undertaken in 'groups linked to one another', with farmers undertaking a 'systems approach' when it comes to adoption practices.</p> <p>This occurs even if such a set of practices may be less than desirable (such as long fallow), occurring in low rainfall environments, more than likely an extremely conservative risk management approach.</p> <p>Innovative practices (such as selective grass weed control) have strong associations with a host of other weed-control related practices, indicating a systems approach to technology adoption.</p>
<b>Implications associated with 'Best Practice' relationships</b>		
<p>'Best practice' technologies tended to be linked to one another, in terms of adoption of groups or clusters of related practices and techniques.</p> <p><i>This is indicative that technologies are not adopted in a 'piece meal' fashion, in that farmers generally take a 'sequential adoption' approach to adopting groups of related technologies and farming practices. As a result, it is important that extension delivery programs likewise take on a systems approach, and the implications of such extension messages are clearly understood and taken into consideration.</i></p>		

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Characteristic	Key outcome / result	Comments and interpretation
<b>Agricultural Knowledge Systems and information characteristics</b>	<b>Electronic and information sources;</b> most weekly accessed printed source was "The Stock Journal" by 81.9% of respondents, whilst "The ABC Country Hour" was accessed by 64.6%. 92.5% of respondents never utilised the Internet. Most useful was the ABC Country Hour (62.2% rating source as useful to extremely useful)	The majority of farmers access information from readily available information sources. There is little evidence of the Internet providing valuable information to respondents (at the time of the survey)..
	<b>Personal information sources;</b> 96.1% accessed information from their neighbours, 93.7% from chemical resellers, only 30.8% from an agricultural consultant. The most highly valued personal information source were agricultural consultants, where 83.5% of respondents who utilise their services provided a rating of either 'useful' or 'extremely useful'	Personal information sources are widely accessed by respondents, with 'other farmers' providing the most common information source, followed by chemical resellers. The most valued information source considered were agricultural consultants.
	<b>Participation in group activities;</b> was dominated by the Agricultural Bureau, where 67.5% of all respondents were regularly involved in activities. The most valued group activity was TOPCROP, where 71.7% of those involved in the program provided a rating of either 'useful' or 'extremely useful'.	The Agricultural Bureau is the most widely accessed group based activity, but not necessarily the most valued.
	<b>Decision-making processes</b> associated with crop sowing operations were the focus of discussion at a number of case-study sessions. Key questions included; How critical is the timing to sow the crop (potential yield losses due to delayed seeding versus potential for frost risk?); Information gathering: What are my neighbours doing? What are my own past experiences and strategies? Seeding conditions: What are the seed bed conditions like, will the seed germinate? What order will I sow the crops in?	It is evident that there are many factors that are taken into consideration when farmers contemplate their crop sowing operations. Issues relating to what other farmers "are doing", past experience and the individual management of risk are major considerations that influence farmer decision-making in a complex environment.
	<b>Social networks – case study session with focus groups;</b> It was considered that farmers now had far greater access to information from a much wider range of information sources than 15 or more years ago. Social conversation provided opportunity to discuss and compare with other individuals farm decisions and practices.	It is evident that farmers value open discussions with one another, and developing networks in which they can share this information. This was described by some as a form of "peer review" or "mentoring", a distinct characteristic of the Agricultural Knowledge System.
	<b>Characteristics of information providers;</b> If information is to be valued the farmers need it from credible and trusted sources (credibility develops over time). The ability to see the results in the paddock, on soil types / conditions that reflect local farming conditions were considered essential if adoption of a product or practice were to take place. It was considered important to look towards what other local farmers were doing at the time. Other farmers to which advice could be sought weren't necessarily the leading farmers, but farmers to who the information seeker could assimilate with. Farmers considered that credibility develops over time, as the experience of the individual develops. One workshop group commented "you need to get used to the personality of the agronomist - it takes a few years in order to get that trust".	Workshop participants considered that the credibility associated with a person was reflected through their ability to have a sound knowledge of the local area, and an ability to identify the needs of the person they are dealing with, in addition to having sound communication skills, notably an ability to listen. Credibility and trust in an information source develops over time, with locally based advisers being the most trusted.

**Implications associated with 'Agricultural Knowledge Systems'**

Some primary sources of information provide a baseline of awareness relating to farming practices, such as The Stock Journal and The ABC Country Hour. Such sources are generally accessed by all across the farming population. Likewise, in terms of personal information sources, 'other farmers' or 'neighbours' are also a primary source of information, accessed across the farming population – often this involves a process of 'peer review or mentoring' as some farmers described. There are differences in the types of information sources accessed between 'conservative' and 'innovative' farmers – with 'conservative' only accessing the basic information sources such as The Stock Journal and Country Hour. It is evident that there are social pressures relating to the adoption of innovations and farming practices, with often the non-adopters being viewed as a local 'benchmark' for the more innovative farmers to compare their advanced systems with traditional practices. The credibility associated with 'information providers' develops over time, as part of 'trust'

**Basic information sources such as 'The Stock Journal', 'The ABC Country Hour' and other farmers (neighbours) are useful in accessing a large number of farmers, and serve as a valuable tool in creating awareness about a particular practice or innovation. These sources are not necessarily the most influential, in terms of introducing practice change on-farm. Characteristic to the Agricultural Knowledge system are social pressures evident in relation to adoption of best practice within rural communities, often 'conservative' or 'traditional farmers' acting as benchmarks to the more innovative farmers. It is important that when developing extension delivery systems, an understanding of the outcomes to be achieved are fully understood, and the most appropriate information sources are selected. Community pressures, and social influences do have an impact on adoption, an understanding of these is essential in order to better develop delivery systems, and who is targeted in the Agricultural Knowledge System is critical.**

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Characteristic	Key outcome / result	Comments and interpretation
<b>Adoption characteristics</b>	<p><b>Comparisons between information sources that led to awareness of an innovation versus those sources most influential in leading to adoption</b> were compared for a range of technologies. In the case of minimum tillage, awareness of the technology by 18.2% of respondents was sourced from 'other farmers', with 36.1% of respondents considering that 'other farmers' were the most influential source to 'try the technology out'. In other examples, such as crop monitoring, the source creating the awareness (for example Agricultural Bureau, acknowledged by 23.9% of respondents) was not necessarily the most influential (13.4% quoting the Agricultural Bureau).</p>	<p>There are differences between information sources, in terms of those sources that may generate 'awareness' of an innovation, versus those sources that are considered 'most influential' in relation to a farmer 'trying an innovation' out.</p> <p>This requires the approach to consider first the characteristics of the technology, and from which source is likely to have greatest influence over farmer behavioural change.</p>
	<p><b>Adoption of 'best practice' rates</b> were compared for a number of different practices. Some basic practices were adopted by more respondents, such as "monitoring weeds prior to herbicide use" (85.2% State average), with regional responses ranging from 77.3% on Eyre Peninsula to 92.8% in the South East. Other more complex techniques such as "using narrow points on seeding equipment" achieved an adoption rate of just 19.3% (State average), with rates of adoption ranging from 10.1% on Eyre Peninsula to 31.7% in the South East.</p>	<p>It is evident that the level of adoption varies according to the particular innovation, and the particular region of the State. The characteristics associated with the particular practice, such as relevance to local farming environments, the degree of risk associated with the practice, and the perceived need to adopt the particular practice are all factors that may influence the level of adoption on a regional basis.</p>
	<p><b>Awareness and adoption levels</b> of a range of practices were sought from respondents, with farmers had a relatively high level of awareness relating to the different technology examples presented. There was a greater variability in the percentage of farmers who had actually tried the technology, ranging from 31.3% of farmers having tried 'rowing canola' to 81.3% of farmers who had adopted 'crop monitoring systems'.</p>	<p>Farmer awareness of a particular practice did not necessarily lead to adoption. Rates of adoption of particular practices vary across regions, depending on the relative intensity of the farming system, the risks associated with the technology/practice and the perceived relevance of the technology.</p>
	<p><b>Continuance in the adoption of an innovation</b> occurred where the perceived benefits associated with that technology remained (or benefits/pay-off were soon expected). In some instances farmers were still evaluating the technology, not committing themselves either way.</p>	<p>The benefits associated with a given technology need to be real and evident, in order for adoption to continue. Adoption is not instantaneous, but can occur over a period of time whilst the farmer is evaluating that technology.</p>
	<p><b>Non-adoption of an innovation</b> was characterised by respondents considering that there were no perceived benefits or advantages associated with the practice, with other reasons cited such as 'lack of knowledge' or 'not suited to my farm'.</p>	<p>Non-adoption will occur where the technology is considered to offer no specific benefits (including economic), or not suited to the respondents' farming environment, a natural response from a farmer.</p>
	<p><b>Dis-adoption of an innovation</b> occurred as a result of a number of factors, such as the perception of the practices offering "no benefit", 'difficult to implement', or not suited to the respondents' farm.</p>	<p>It is evident that there are logical reasons as to why dis-adoption of particular farming practices occur. These reasons need to be viewed within the operating environment of the farmer.</p>
	<p><b>Time-lag to adoption</b>, defined as from the time when the respondents first became aware of the particular technology to when adoption took place was measured for a range of innovations. Time-lag was less for 'simple technologies' (for example growing a new wheat variety 462 days) compared with 'more complex' technologies (minimum tillage 1302 days)</p>	<p>The more complex the technology, the longer the period of time between respondents first 'becoming aware' of the technology and the time in which 'adoption' takes place. Adoption is not necessarily an automatic response to behavioural change, with the decision to adopt taking time.</p>
	<p><b>Relationships between adoption rates and annual rainfall</b> were compared for a range of 'best practice' farming technologies. Comparisons indicate that in marginal districts there are no practices that fall into the high category of adoption (90% and above total adoption).</p> <p>In the high rainfall districts, all practices achieved a rate of adoption in excess of 50%; as growing season rainfall increases, so does the relative rate of adoption of the various farming practices.</p>	<p>Results indicate that basic practices are widely adopted across all rainfall zones. As the specific practices become more complex (with higher elements of risk attached to them), the rates of adoption are lower in the low rainfall environments.</p>

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Characteristic	Key outcome / result	Comments and interpretation
<b>Adoption characteristics</b> <i>continued</i>	<b>Adoption of no-till systems (case study)</b> , participants considered the adoption process to be a step by step process; first becoming aware of the technique, seeking information from others; looking to the experiences of other farmers; consciously making a decision to try the new technology (often leading to an extended period of trial and error); modifications of specific seeding techniques in order to adapt to local cropping conditions and needs.	Adoption of no-till seeding systems occurs in a logical 'step-wise' fashion. It tends to be a continuous process, often with an extended period of 'trial and error'.
	<b>Quartile comparisons for adoption rates</b> were undertaken, comparing the characteristics between the 'top 25%' with the 'bottom 25%' of adopters. Those respondents referred to as "high adopters" who were in the top 25% quartile for level of adoption of innovation were found to be younger, with less farming experience than "low adopters" (those respondents in the bottom 25% of the population). "High adopters" were less conservative, more positive about the long-term outlook of farming (farm financial viability), and had a higher "land stewardship" score. In terms of equity, "high adopters" had slightly lower equity (85.1% in comparison to 86.6% for low adopters), but had significantly higher borrowings (\$185,000 in comparison to \$105,000), and total property value (\$1,094,000 compared to \$705,000).	Specific differences in terms of the personal and situational characteristics of respondents are evident, when comparing characteristics associated with the quartiles relating to the number of practices adopted by farmers.
	<p><b>Adoption and risk management</b> was a theme from the focus group workshops. Discussions arising from the workshop case studies often provided an emphasis upon risk management and adoption. Workshop participants in many instances were of the opinion that many of the decisions made on farm tended to be complex in nature, due to the degree of relationships between variables and the farm business system. It is evident that participants believed that the level of adoption is influenced by an individuals' attitude to risk, and whether or not farmers were comfortable appearing to "go out on a limb" with their adoption (relating back to community pressures).</p> <p>Some workshop participants believed that many of the older farmers in their district live in a comfort zone of their own, "they don't necessarily have to look after the land, they complain about not being able to get the pension, but have too many assets", is one comment from a workshop participant. Participants believed that often there was a perception amongst older farmers that they did not have the capacity to pay off farm debts, hence there was a very high degree of farming conservatism practiced.</p> <p>Participants felt that one of the main barriers to the uptake of new technology was farm size. As a result, technology was being adopted in a piece meal fashion, due to the high costs of investment required in new technologies.</p>	<p>On-farm decision-making is complex in nature, with many intervening variables. Attitude to risk and past experiences influence the adoption decision.</p> <p>Older farmers tended to have a greater risk-aversion, and less inclined to change their farming systems, and may have less incentive to adopt new practices, particularly if they are near to retirement.</p>
<p><b>Implications associated with 'Adoption characteristics'</b></p> <p>There are a large number of factors that influence the adoption process on-farm. Whilst a range of information sources create an awareness of a specific practice, they may not necessarily be the most influential, in terms of adoption processes. The management of risk by farmers is of significance in relation to the decision to adopt the particular practice, this is particularly important in low-rainfall farming environments. There are logical reasons as to why non-adoption and dis-adoption take place. The nature of the innovation, in terms of its relative complexity and ease of adoption will likewise influence the adoption process. Not all of the farming audience have the desire (or the capacity) to adopt new practices, and many are quite comfortable with their current systems (linked to their specific life-stage as well), with older farmers being less likely to adopt, having higher levels of risk aversion and conservatism. There are community pressures evident in relation to the adoption of new technologies, with often the 'conservative' types of farmers being viewed as 'benchmarks' by the more progressive farmers whom are aiming to improve their farming systems.</p> <p><b><i>To whom the extension message is directed, and the avenue of delivery is critical to achieving adoption. The adoption environment is extremely complex, with a wide range of intervening variables and characteristics. Not all respondents will be in a position to adopt; they may not have the desire to, or the capacity. Extension delivery systems need to be well targeted, segmentation of the audience will assist in achieving higher levels of adoption success.</i></b></p>		

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Characteristic	Key outcome / result	Comments and interpretation
<p><b>Principal Component Analysis (PCA)</b></p>	<p>The variability in the population (59.9% variance) can be explained by the first four principals. The most dominant variables for each particular Principal Component are presented in the following (each principal has also been assigned a descriptive title, representing the most dominant variables for each).</p> <p><b>Principal 1: "The innovators"</b>            Influencing variables include high adoption, high productivity, high levels of education, readily accesses information, low conservatism and relatively less experience in farming. This principal is very descriptive of the characteristics associated with innovative farming practices.</p> <p><b>Principal 2: "No need to change"</b>            Influencing variables include low crop area, high rainfall, high yields, conservative in nature and lower education levels. This principal is closely associated with those farmers who farm in high rainfall, reliable farming districts, possibly mixed farming (incorporating livestock) operations, and being conservative in nature.</p> <p><b>Principal 3: "Experienced and successful"</b>            Influencing variables include high equity, high levels of experience and low education. This principal captures those respondents who have been involved in the industry for a number of years, having high levels of business equity, but lower levels of formal education.</p> <p><b>Principal 4: "Building the farm business"</b>            Influencing variables viability concerns, lower equity, readily access information, high adoption. These respondents may be in the early stages of their "farm business cycle", having concern for future business viability as a result of lower equity. They have ready access to information, and readily adopt new farming practices.</p>	<p>The Principal components helped to explain the nature of the variance in the population, with the first principal accounting for the most variation in the population, with each preceding principal accounting for reducing amounts. From this, it is evident that a key influence associated with the data is reflected through the first principal, tagged as 'innovativeness'.</p> <p>The second most significant principal related to 'no need to change' a group of conservative related influences where the motivation for change may be less (lower education levels, high rainfall districts).</p> <p>Principal three was characterised by highly experienced (older) individuals, having high levels of equity, but not necessarily education.</p> <p>The characteristics associated with principal four include younger farmers, lower equity, and more of a tendency to adopt new technologies.</p>
<p><b>Implications associated with farming typology</b></p> <p>The PCA has been useful in terms of identifying the characteristics (or factors) that are responsible for variance associated with the survey population. This is a significant process in the analysis and interpretation of the data, in terms of establishing the statistical significance and association within the survey data set. Rather than relying upon the perceptions of the researcher, the PCA has provided the opportunity to establish the linkages between specific characteristics associated with the survey data set.</p> <p><i>Results from the PCA is useful in terms of establishing the relationships between the characteristics associated with the survey population. It is with this knowledge that the next stage of analysis (k-means cluster analysis) proceeded. The results obtained provide a detailed overview of the relationships and characteristics associated within the data set. As indicated earlier, the information arising from the study is extremely complex in nature. Key elements from the survey responsible for variance within the population identified through the PCA included innovativeness, conservative related characteristics, equity, experience, information and adoption.</i></p>		

APPENDIX T continued

Characteristic	Key outcome / result	Comments and interpretation
<p><b>k-means cluster analysis</b></p>	<p><b>Cluster 1 'extremely conservative at risk'</b> (n=19) farmers have low rates of adoption, information access, education, experience in farming, low equity, lower farm area and are concerned about their future farm viability. For these farmers the future for them does not look particularly positive.</p> <p><b>Cluster 2 'progressive but non-viable'</b> (n=83) farm in a high rainfall environment, have high rates of adoption and information access. Farmers have high levels of farming experience and have above average equity in their farm business, but low farm area.</p> <p><b>Cluster 3 'low rainfall and innovative'</b> (n=337), innovative, located in a low rainfall environment (but not to the same extent as cluster 5), have less arable land available than cluster 5, but achieve higher yields with similar levels of equity. Overall, the variability in the characteristics measured were quite small, indicating that this cluster were representative of the "average profile" of respondents participating in this study.</p> <p><b>Cluster 4 'the risk manager'</b> (n=25) farmers tended to manage risk more so than other clusters. This cluster had moderate rates of adoption (though adoption was slower), lower education levels, produced lower yields and were older, but had good equity levels.</p> <p><b>Cluster 5 'the big low rainfall cropper'</b> (n=23) is characterised by large farm area, marginal rainfall and relatively low wheat yields. Overall farming operations are considered viable reflected in favourable equity. Farmers are not conservative in attitude, and average levels of adoption.</p> <p><b>Cluster 6 'conservative and no need to change farmers'</b> (n=233) could be described as those who are "ready to retire" being extremely conservative, with no real pressure on them to change their farming behaviour.</p> <p><b>Clusters 7 'young innovator, high adopter'</b> (n=44) medium rainfall, have less 'farming experience and conservative in nature. Farmers have high rates of access to information, tend to be high adopters of farming practices, slightly higher levels of education and sound equity in their business</p> <p><b>Cluster 8 'future concerns'</b> (n=76) farmers tended to be in the middle age range (based upon level of experience), and held concerns in relation to their viability. They tended to be responsive to change.</p> <p><b>Cluster 9 'the master farmer- innovative and productive'</b> (n=200) are characterised by farming in a high rainfall environment, have high rates of adoption and information access.</p> <p><b>Cluster 10 'young innovative farmer – taking the risks'</b> (n=76) farm in "medium rainfall" environment have low "farming experience" and being "conservative" in nature, have moderate levels of education, and moderate farm equity. Farmers may be involved in a process of "farm build-up", reflecting higher debt levels and lower equity levels.</p>	<p>The cluster analysis illustrated that "farmer age" features prominently. "Older farmers" were a feature in three of the clusters (clusters 1, 4 and 6, comprising 25.8% of the survey analysis population). Accompanying characteristics included a high degree of 'conservatism', lower rate of adoption, and low rate of information access. In contrast to this, younger farmers, with associated characteristics of high information access, higher rate of adoption and innovativeness were associated with three clusters (5, 7 and 10, comprising 12.9% of the population).</p> <p>This analysis provides an overview of "group like" characteristics within the survey population, providing the opportunity to target specific sectors of the population, in order to optimise impact of the extension activity.</p>

**Implications associated with the cluster analysis**

This k-means cluster analysis has provided an ability to objectively examine the characteristics of specific groupings of the population arising from the principal component analysis. The characteristics of these groups have been described in a manner in which the adoptive behaviours of the groups can be interpreted. The specific linkages between the variables used in the analysis provides the basis of establishing statistically significant relationships present in the data set, and population.

***This information does have implications in terms of how extension programs and systems are developed. The k-means cluster analysis has established specific associations between the specific characteristics of the population, through the identification of specific clusters – and having the ability to describe them. As a result, a formal segmentation of the population has been established, with each group being described from a 'typology' sense. With a knowledge of these characteristics, it is now possible to specifically target certain segments of the population for any given extension program. This will assist in the delivery of a specific technology, within the context that takes into consideration the characteristics associated with the targeted market segment.***

**APPENDIX U: Comparison of studies relating to identification of farming typologies based upon socio-economic influences and derived through principal component analysis and/or k-means cluster analysis**

Title of research paper	Target population	Key findings	Key attributes and limitations to the study
Emtage, N., Suh, J.,(2005) ' <b>Identifying typology of households based on the characteristics of their farming land and livelihood systems</b> ', University of Queensland e print, < <a href="http://eprint.ug.edu.au/archive/00003826/01/28_Nick_Identifying_Typology.pdf">http://eprint.ug.edu.au/archive/00003826/01/28_Nick_Identifying_Typology.pdf</a> >, accessed 16/07/06.	203 Farm households, Philippines, k-means cluster analysis involving 4 variables, land area, proportion step land, household income, and income derived from farming.	Four groups identified, and characteristics associated with those groups described. Typology identified has the potential to provide an understanding of the influences on socio-economic factors. It was suggested that different "runs" of variables be performed, using the same data and changing the variables, in order to establish validity of the data.	Analysis of the data using the k-means cluster analysis provided the opportunity to capture unknown typology of the households, in terms of identifying livelihood systems in an exploratory manner. It is recommended to utilise multivariate analysis (including principal components analysis and factor analysis) as they do not have a dependent variable (to be explained by an independent variable)
de Lauwere, C.C., (2005), ' <b>The role of agricultural entrepreneurship in Dutch agriculture of today</b> ', <i>Agricultural Economics</i> 33, 229-238	Telephone survey involving 752 Dutch farmers	Data identified 5 distinct groupings of farmers on the basis of their "strategic orientations". Based on results of the analysis, typologies were described as social, traditional, new, indecisive and prudent farmers. The k-means cluster analysis allowed for the identification of "separate groups of farmers – or farming styles based on their strategic orientation"	The study was able to identify the personal characteristics associated with successful farmers. Positive "tough" characteristics affect agricultural entrepreneurship positively, with negative personal characteristics affecting it negatively. The study was derived from responses to specific questions (attitudinal statements).
Gunderson, M.A., Boehlje, M.D., Gray, A.W., (2005), ' <b>Segmenting Agribusiness Customers on Their Capital Expenditures</b> ', paper submitted to the 2005 International Food and Agribusiness Management Association, World Food and Agribusiness Symposium	Large commercial agricultural farmers in the USA, 2000 survey responses. Written responses to a postal questionnaire	Cluster analysis used the following variables; farm size, age, education, internet use, technology adoption rate, loyalty to local supplier, purchasing behaviour (on price), brand loyalty, and potential farm production growth. Cluster analysis Identified four clusters, these being 'Relationship', 'Economic', 'Business' and 'Balanced' Buyers. This model would then allow the agribusiness company to create what the researchers describe as a "customer scorecard", to manage customer base, through identification of the relative profitability associated with each of the identified clusters.	A model was then developed, which aimed to predict the "customer segment" based on the characteristics of the particular farmer. This included the identification of specific characteristics of a farmer that were considered to be associated with each specific cluster. For example, specific questions relate to the following; Does the producer enquire about price? Do they have a Degree? How long have they had an established relationship with the supplier? Likely behaviour – more price sensitive, less loyalty more likely, higher education more likely. Likely to be in the Economic Segment (cluster), characterised by "Price buyer", Education and supplier loyalty.

Title of research paper	Target population	Key findings	Key attributes and limitations to the study
Maybery, D., Crase, L., Gullifer, C., (2005) <b>Categorising farming values as economic, conservation and lifestyle</b> , <i>Journal of Economic Psychology</i> 26 (1) 59-72	552 Australian farmers from the NSW Murray region, surveyed through questionnaires, focus groups and interviews	Principal component analysis conducted identified three specific factors relating to the goals and objectives of farmers, within the context of economic, conservation and lifestyle factors.	The study set about to identify if farming values could be categorised according to economic, conservation and lifestyle, based upon the goals and objectives held by a population of farmers. There was little emphasis in relation to environmental and situational factors that may also describe farmer behaviour.
Ravnborg, H.M., Rubiano, J.E. (2004), <b>'Farmers' decision making on land use – the importance of soil conditions in the case of Rio Cabuyal watershed, Colombia</b> , <i>Danish Journal of Geography</i> 101: 115-139.	Sample of 198 households, focussed on farmers' decisions in relation to land use and land condition, conducted in Colombia.	Clusters identified on basis of "soil quality" from poor to good. Variables used included physical soil condition characteristics, distance of the plot to roads, farm size and farming intensity.	The study revealed that socio-economic factors are significantly more responsible for explaining farmer's decision-making, as opposed to relying on the analysis of biophysical conditions. The study was orientated to analysis of the physical characteristics of the environment.
Shinns, L.H., Lyne, M.C., (2003), <b>Symptoms of poverty within a group of land reform beneficiaries in the midlands of KwaZulu-Natal: analysis and policy recommendations</b> , University of Wisconsin-Madison	38 Rural households in a resettlement area South Africa	PCA and k-means cluster analysis used to identify different dimensions of poverty affecting population. Five clusters identified, with poverty profiles for each described; income and asset rich, asset rich but income poor, income rich but asset poor, income and asset poor living in a state of chronic poverty	Study focussed on the symptoms of poverty, but did not set out to identify the underlying causes. Study did identify the different situations and characteristics associated with the households.
296 Michielsens, C.G.J., Lorenzen, K., Phillips, M.J., Gauthier, R., (2002), <b>'Asian carp farming systems: towards a typology and increased resource use efficiency'</b> . <i>Aquaculture Research</i> 33, 403-413	Asian carp farms, 2493 farms from nine countries. Study focussed on the characteristics of the farms involved in the study, 12 composite variables used in the analysis	Clusters identified were described as Super-intensive systems, Intensive systems, specialised semi-extensive systems, and integrated semi-extensive systems.	Previous means of classifying aquaculture farms were based upon conceptual as opposed to empirical means of classification, and tended to be uni-dimensional in nature. The analysis however fell short of capturing the true complexity of the farm fishing systems. The study focussed on the physical characteristics of the farming operation, as opposed to inclusion of the social characteristics.
Thomson, D., (2001) <b>'Different pebbles, same pond: Farming styles' in the Loddon catchment of Victoria</b> , APEN Network, International Conference 3-5 Oct 2001, QLD.	Loddon catchment of rural Victoria, 366 survey respondents from a mail-out of 1,000 surveys.	10 specific groupings of respondents identified through k-means clustering, based on responses to 31 attitudinal and goal statements relating to farming. From this, the clusters were described as 'farming styles'	Ten specific styles were identified, considered useful in developing targeted extension programs. Data used in study was based on responses to range of statements, as opposed to collecting conclusive 'hard data' relating to the personal and situational characteristics of the targeted audience.
Bernhardt, K.J., Allen, J.C., Helmer, G.A., (1996), <b>'Using cluster analysis to classify farms for conventional/alternative systems research'</b> , <i>Review of Agricultural Economics</i> 18:4, 599-611	59 cropping practice variables used to analysis farm classification on the basis of "conventional" and "alternative" production systems, involving 265 Nebraskan farmers .	Five cluster groups identified, these were labelled in order to "simplify the recognition of management profiles" (Bernhardt et al 1996). The groups identified were Irrigated-Monocroppers, Young-Business-Technocrats, Integrated, Near-Organis and Urban-Fringe.	Cluster analysis provided unbiased classification, however data provided for analysis is based on the bias of the researcher – this needs to be derived form a conceptual model that is defensible. Cluster analysis identifies natural clusters, but the analysis was limited by the size of the clusters (from a total no. of respondents of 265) Study was limited by only adopting one clustering method.